Continuity or Change? The Evolution in the Location of Industry in the Netherlands and Belgium (1820 – 2010)

Robin C. M. Philips

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Continuïteit of Verandering? De Evolutie van de Locatie van Industrie in Nederland en België (1820 - 2010)
(met een samenvatting in het Nederlands)

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Image on first page: Vincent van Gogh. Watercolor, Pencil, transparent and opaque watercolour, pen in brown ink, on laid paper. Nuenen: December - August, 1883 – 1884. Propriety of the Van Gogh Museum Amsterdam, The Netherlands, Europe. F: 1115, JH: 502

Summary

What explains the location of industry in the Netherlands and Belgium since the beginning of the nineteenth century until present? This thesis explains the regional patterns of industrialization and economic development in the Low Countries through various phases of (de-) industrialization, during the 1820s-2010s, by drawing upon new datasets which combine recently-digitized industry and population censuses and previously undigitized archival sources.

The first part of the thesis tests the importance of proto-industry for the Industrial Revolution, where we assess that in some regions such as the Eastern Netherlands the location of modern industry geographically overlapped with the location of proto-industry, whereas other regions such as Flanders modern industry developed outside the proto-industrial heartland. The second part analyses the causes of the first and second Industrial Revolution. While during the first half of the nineteenth century industries predominantly emerged in regions with illiterate and cheap labourers, an evolution of which the Belgian regions benefitted more than their Dutch counterparts, during the second part of the nineteenth century high-skill intensive industries emerged mostly near regions with a highly-skilled labour force. The third part studies the determinants of industrial location during the twentieth century, where we observe industries increasingly clustering in centres of market potential and human capital, away from neo-classical factor endowments such as natural resources and agricultural production, explaining in part the relocation of industries in Belgium from south to north and in the Netherlands to the western part of the country. In the last part, we test the resilience of regions against the disappearance of manufacturing jobs in the last decennia. Our results indicate that the long-term presence of industrial sectors could limit the capabilities for some regions to develop new economic activities, in particular though not exclusively located in the Belgian Mons-Liège rust belt.

Thus, this study attempts to provide a better understanding of the evolutionary dynamics of the location of industry. Since the beginning of the nineteenth century until present, different determinants for the location of industry – related to differences in factor endowments, market potential, and institutions – have altered the industrial landscape. Yet, this study affirms regional and national differences in these determinants of industry. Also, path dependence is found to have played an important role. The previous determinants of industrial development and the existing economic structures resulting therefrom appear able to strengthen or weaken the attractiveness of a region for new industries, and alter the capabilities for a region to become economically resilient or vulnerable in the long-run.

Samenvatting (Summary in Dutch)

Wat verklaart de locatie van industrie in Nederland en België sinds het begin van de negentiende eeuw tot vandaag? Dit proefschrift onderzoekt de regionale patronen van industrialisatie en economische ontwikkeling in de Lage Landen doorheen verschillende fasen van (de-) industrialisatie tussen 1820 en 2010, door gebruik te maken van nieuwe datareeksen die recent gedigitaliseerde industrie- en volkstellingen combineren met tot dusver ongedigitaliseerde archiefbronnen.

In het eerste deel van het proefschrift testen we het belang van proto-industrie voor de Industriële Revolutie, waarbij in sommige regio's zoals in Oost-Nederland de locatie van moderne industrie geografisch blijkt te overlappen met de locatie van proto-industrie, terwijl in andere regio's zoals in Vlaanderen de moderne industrie zich ontwikkelde buiten het proto-industriële kerngebied. Het tweede deel behandelt een analyse van de oorzaken van de eerste en tweede Industriële Revolutie: terwijl tijdens de eerste helft van de negentiende eeuw industriesectoren zich vestigden in regio's met voornamelijk ongeletterde en goedkope arbeidskrachten, een evolutie die de Belgische regio's meer ten goede kwam dan de regio's in Nederland, vestigden in de tweede helft van de negentiende eeuw hoogtechnologische sectoren zich in het bijzonder in regio's met veel hooggeschoolde arbeid. Het derde deel onderzoekt de determinanten van de locatie van industrie doorheen de twintigste eeuw, waarbij we observeren dat industrieën zich clusteren in locaties met toegang tot markten en menselijk kapitaal, ten voordele van locaties met toegang tot neoklassieke productiefactoren zoals natuurlijke hulpbronnen en landbouwproductie, wat ten dele de relocatie van industrie in België van het zuiden naar het noorden en in Nederland naar het westen van het land verklaart. In het laatste deel testen we de veerkracht van regio's tegen de verdwijning van arbeidsplaatsen in de maakindustrie tijdens de laatste decennia. De resultaten tonen aan dat een langdurige aanwezigheid van industriesectoren de ontwikkeling van nieuwe economische activiteiten in de weg kon staan in bepaalde regio's in de Lage Landen, met name maar niet exclusief gelokaliseerd in de Belgische Sambre en Meuse vallei.

Aldus poogt deze studie een beter inzicht te geven in de evolutionaire dynamiek van de locatie van industrie. Sinds de negentiende eeuw tot vandaag blijken verschillende aantrekkings- en afstotingsfactoren, gerelateerd aan regionale verschillen in productiefactoren, toegang tot markten, en instituties, verantwoordelijk te zijn voor verplaatsingen in het industriële landschap. Desalniettemin toont deze studie substantiële nationale en regionale verschillen in deze vestigingsfactoren. Tevens blijkt pad-afhankelijkheid een bepalende rol te spelen. De vroeger bepalende factoren voor industriële ontwikkeling en de daaruit voortvloeiende bestaande economische structuren kunnen de aantrekkelijkheid van een regio als vestigingsplaats voor nieuwe industrieën zowel versterken als verzwakken, en de capaciteiten beïnvloeden die een regio succesvol of kwetsbaar maken op de lange termijn.

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Robin C. M. Philips

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Chapter 1. Introduction

1.1. Background

The Industrial Revolution and its aftermath as we know it today, proved to be a watershed in human history by not just changing labour structures, but also income levels and even our world view. As this event is recognized by many authors as the radical break with the rather stagnant nature of economic development in the preceding centuries of human history, it is not surprising that the process of industrialization has been affiliated with many superlatives such as "a great transformation" (Polanyi 1944), "a rapid take-off" (Rostow 1960), "the unbound Promotheus" (Landes 1960), "a great spurt" (Gerschenkron 1962), or even the "fundamental turning point in history" (Bairoch 1963). All these authors provide us with a similar view on industrialization: starting with the Industrial Revolution in 18th century England, soon thereafter the new technologies and production methods spread as a slick of oil to continental Europe, with the rest of the world pursuing this path to modern economic growth relatively later. Although these studies argued that the process of industrialization differed over countries, many of these authors hypothesize over a fairly homogenous, linear pattern of industrialization, with countries proceeding through several stages of economic growth, in which changing factors spurred growth in the manufacturing sector over time. Although these theories in the 1960s - 1970s were the first attempts in theorizing the process of industrialization, their views of industrialization attracted considerable criticism with the emergence of new economic history during the last decades.

First, the start of the Industrial Revolution is generally considered not to have been such a "rapid take-off" after all. Rather, the spark of the Industrial Revolution is argued to have built on long-term evolutions in previous centuries, among which an increased availability of cheap labour due to agricultural productivity increases (Clarkson 1985), the increase in demand for manufactured products (Ogilvie and Cerman 1996; De Vries 2007; De Vries 2008), human capital accumulation (Van Zanden 2009), higher levels of urbanization (De Vries 1984), and changes in the female labour participation (De Moor and van Zanden 2010). Additionally, new institutional economics has put forward institutions as a major factor for shaping the transition to the Industrial Revolution and modern economic growth (North 1990). For example, the institutional reforms in the advent of the Glorious Revolution (North and Weingast 1989) and the French Revolution (Acemoglu, Johnson, and Robinson 2005; Acemoglu et al. 2012) are considered instrumental for creating an institutional framework receptive for adapting crucial new technological innovations (Mokyr 2007; McCloskey 2010; Mokyr 2017). In other words: the above studies have argued that the transition from the pre-industrial period to the Industrial Revolution encapsulated in certain aspects rather continuity than discontinuity, with some studies even arguing that the causes of the Industrial Revolution – or even thereafter – have their roots in a pre-modern past.

Second, most of the aforementioned studies look at the determinants of industrialization in a static view. Following Bairoch (1993: 164), who argued that "there is no law or rule in economics that is valid for every period of history or for every economic structure", similarly Polanyi (1944), Kuznets (1955), Rostow (1960), Landes (1960), Gerschenkron (1962), and Bairoch (1963) stressed the relevance of different factors for industrial growth during different episodes of industrialization. Yet, recent empirical evidence has brought forward a more nuanced picture, in which the determinants of the Industrial Revolution are argued to share similarities with the drivers of industrialization during subsequent centuries, but changed over time in relative importance. For instance, the seminal work of Kim (1995) showed that the distribution of factor endowments continues to explain the location of industry in the USA during 1860-1987. Similarly, Betran (2011) revealed the continuing importance of factor endowments as mining inputs and agricultural inputs for the location of industry in Spain during 1856-2002, whereas market potential and human capital endowments increasingly became important during the twentieth century. Yet, even though it is recognized that other factors increasingly came to drive the location of industrial activities over the last centuries, studies that model the determinants of industry over long time periods are rare.

To these two sources of critique, we may add a third, namely that most of the empirical and theoretical contributions apply the causes of industrialization to countries, whereas the national level, though informative, might cover up notable evolutions. Since the 1980s, scholars have put regional industrialization processes increasingly on the international research agenda, with Sidney Pollard (1981: VII) arguing that "this [industrialization] process is essentially one of regions" and Patrick O'Brien (1986: 297) suggesting that "industrialization […] was a regional and not a national process. Modern industry certainly did not spread randomly over the map of Europe but 'clustered' within defined geographical boundaries". Indeed, while all aforementioned studies agree that the Industrial Revolution found its origin in the British economy at the end of the 18th century, the great regional variety in terms of the supply of labour and capital (Crafts and Mulatu 2005), coal availability (Fernihough and O'Rourke 2014) and income levels (Crafts 2005) in England has led to different theories about why this industrial offspring did occur in Lancashire rather than other regions. As most countries faced similar differences in the spatial distributions of factor endowments, income levels, and institutions, the study of spatial patterns of industrialization have drawn increasingly attention in recent decades (e.g. Kim 1995; Crafts and Mulatu 2005; Missiaia 2019). But, even today, regional differences seem to occur. Although the explanatory power of these regional differences declined over time, as differences in wages, raw material prices and transportation costs compressed over the twentieth century (e.g. Crafts and Mulatu 2006), the location of industry has continued to change during recent decades, with industries relocating to other regions, in which this process certainly did not confine itself to national boundaries.

Although these three sources of criticism have brought forward some interesting empirical evidence that has revised – on certain points – the classical theories of industrialization (Polanyi 1944; Kuznets 1955; Rostow 1960; Landes 1960; Gerschenkron 1962; Bairoch 1963), the incorporation of both streams of literature has been problematic. Furthermore, the connection between theory and empirics has been hindered by the lack of integration between empirical and theoretical studies, preventing an updated view on industrialization in the long-run. Therefore, in this manuscript, we intend to bring together these classical theories on industrialization, the recent literature in new economic history, and empirical evidence in one coherent framework. As such, we hope to offer an updated answer to the question raised by the classical theories on industrialization on how and why industrialization spread across regions and over time. For this, we study the patterns of regional industrial development throughout the nineteenth and twentieth century in two small Western European countries, the Netherlands and Belgium. As a focal point of attention, we aim to address this question by studying how the location of industry changed in these countries during 1820-2010, and what factors and theories can explain the spatial distribution of industry over time. Therefore, we first turn to the theories which hypothesized about the determinants of industrial location in the past two centuries (see section 1.2.), and particular in the Low Countries (see section 1.3.), based on which we formulate our main research question. Next, we introduce the main sources which we use to answer this main research question (see section 1.4.). Lastly, we present how we set out to answer this question systematically, and how the manuscript is structured (see section 1.5.).

1.2. An unresolved debate: theories on the location of industry

How and why did industrial activities spread across regions during the last two centuries? When turning to the literature to answer this question, we find a vast amount of publications. Although there are various meaningful ways in which we can look at these studies, one interesting possibility is to combine those studies dealing with the rise of modern economic growth on the one hand and those that deal with regional shifts in the more recent periods on the other hand, which allows us to look for long-run drivers of industrialization across two very different phases, i.e. the starting phase and the subsequent phases. On the one hand, economic history studies which explain the dawn of modern economic growth and the offset of the Industrial Revolution are plentiful (e.g. De Vries 2007; Clark 2007; Mokyr 2007; Allen 2009; Van Zanden 2009; McCloskey 2010; Wrigley 2010). On the other hand, many studies have tested for the determinants of the location of industry in the nineteenth and twentieth century, in the fields of economics (e.g. Krugman 1991; Kim 1995; Dumais, Ellison and Gleaser 2002; Davis and Weinstein 2003), economic history (e.g. Crafts and Mulatu 2005; Wolf 2007), and economic geography (e.g. Martin and Sunley 2006; Boschma and Martin 2012). Of course, both groups differ in terms of explanations about what drove industrial growth, presenting us a wide variety of publications. Nonetheless, the theoretical and empirical studies in both groups have more in common than one initially might expect, as they often turn to the same long-run drivers of industrial – or even broader, economic – growth, which can be roughly grouped in three categories: (a) factor endowments, (b) market potential, and (c) institutions.

The availability of factor endowments, especially natural resources such as coal, is perhaps the most influential explanation of the Industrial Revolution. It is no wonder that e.g. Braudel (1981), Wrigley (1962; 2010), Pomeranz (2000), Broadberry and Gupta (2009), and Allen (2011) made the abundance of coal reserves essential to their explanation of why the advent of industrialization can be traced back to 18th century Britain. Initially, due to the high divergence in prices and wages across regions, the proximity to natural resources or agricultural inputs worked as a strong pull-factor for industries (see e.g. Fernihough and O'Rourke 2014). However, as the 19th century proceeded, price convergence and the fall of transportation costs fundamentally reduced the importance of these factors throughout the end of the nineteenth and beginning of the twentieth century (e.g. Crafts and Mulatu 2005; Ronsse and Rayp 2016). Although this process did decrease the concentration of industries over space (e.g. Kim 1995; Betran 2011), evidence on the US (Ellison and Glaeser 1997) and Belgium (Bertinelli and

Decrop 2005) indicates how natural advantages continue their influence for many, mostly resource-intensive, industries until present.

In explaining the industrial rise in England, the debates about another notable factor endowment, human capital, played another interesting role in academic debates. Here, a vast series of economic history studies debated whether the changes in the English labour market during the Industrial Revolution were skill-demanding (see e.g. Meisenzahl and Mokyr 2012; Feldman and Van Der Beek 2016; De Pleijt and Weisdorf 2017), rather than 'deskilling' (see e.g. Nicholas and Nicholas 1992; Goldin and Katz 1998), or even were irrelevant (e.g. Allen 2003). A recent stream of literature argued that the human capital possessed by knowledgeable elites, in contrast to the human capital possessed by the entire labour force, was important as "the Industrial Revolution was carried not by the skills of the average or modal worker, but by the ingenuity and technical ability of a minority" (Mokyr and Voth 2009: 35). In line with the 'unified growth theory' (Galor and Moav 2002), Galor (2011) has argued for an increasing role of human capital on economic growth throughout the nineteenth and twentieth century. Similarly, in line with endogenous growth theories, studies argued that during later stages of economic development a technology-skill complementarity was created, causing a self-reinforcing mechanism of improving levels of human capital and technology that continues until present (Goldin and Katz 1998; Acemoglu 2002).

Secondly, market potential from both domestic and foreign markets has often been presented as an essential factor to explain Britain's lead, as the so-called 'consumer revolution' played a key role in the rapid process of industrialization. Inter alia, Wrigley (1988; 2010), De Vries (2008), and Allen (2009) stressed the role of the increasing purchasing power and trade facilities of the city of London, fuelled by changes in household behaviour (Berg and Clifford 1999; Berg 2004), for the British Industrial Revolution. Of course, in the proximity to consumer markets, transportation costs play a pivotal role. Here, England is argued to have benefitted from a lead as well, with for instance the canal construction playing an essential role for the cheap distribution of coal across regions (Turnbull 1987). Bogart (2005; 2011) went so far in the laudation of the efficient system of railroads, roads and canals, that they titled the 19th century as an age of 'transport revolutions'. During the second half of the twentieth century, convergence in regional incomes due to international and domestic market integration flattened out many differences in regional specialization (Kim 1995; Betran 2011), although agglomeration forces remain an important factor for clustering in particular industries to date. In this stream of literature, agglomeration forces are argued to push industries increasingly together, benefitting disproportionally highly-populated centers of consumers (e.g. Kim 1995; Betran 2011; Rayp and Ronsse 2015).

Other authors stressed the institutional exceptionality of the British Isle, as cultural and socio-political institutions were the explanatory factor for the industrial and economic take-off in England. North and Weingast (1989) famously pointed towards the political consequences of the Glorious Revolution and highlighted its effects on the protection of property rights and the rule of law. Acemoglu et al. (2005, 2011) stressed the effect of these same political reforms on reducing conflict and the improvement of social acceptance towards new technologies, while others emphasized its consequences for the financial market or the overall business environment (e.g. De Long and Schleifer 1993, LaPorta et al. 1998). At present, the impact of institutions on prices and wages is argued to depend heavily on which industrial sector was dominant in the region, as theorized by Hall and Soskice (2001) in their theory on the varieties of capitalism. Here, it is argued that the configuration of institutions leads to different logics for collective action within a given country, which might be more beneficial to certain types of industries than to others.

Thus, there is definitely no shortage of theories about why the Industrial Revolution and the subsequent phases of industrialization favoured particular regions more than others. Needless to say, each of these theories has its own claim to the truth, as the debate about the start of the Industrial Revolution, the second phase of industrialization and the post-industrial phase is heavily embedded in historiographic, economic, and economic-geographic debates. However, the empirical evidence seems inconclusive to assess the relative importance of each of these theories over time, leaving the question open as to which factors were exactly 'game changers' for the localization patterns of industry during the 19th and 20th century. An adequate answer to this question has been blocked by two shortcomings in the empirical studies to date.

Firstly, we find only few studies which are able to study the determinants of industry in the long run. Initially, models were developed to compare the determinants for industrial location based on a limited number of economic indicators, with few studies making an attempt to disprove other factors or test alternative theories. With the emergence of the studies of Kim (1995) and Davis and Weinstein (2003), models were developed that tested the relative importance of the Heckscher-Ohlin theorem, as the main example of the neo-classical trade theory, and the New Economic Geography theorem, which checks for the importance of Marshallian or agglomeration forces. However, it took until the development of the partial equilibrium model by Midelfart-Knarvik et al. (2000; 2002a; 2002b) that an integrated model was developed to estimate the effects of both factor endowments and market potential on the location of industry, thereby making it possible for historians to compare the importance of the Heckscher-Ohlin theorem and the New Economic Geography theorem over time (e.g. Crafts and Mulatu 2005; Wolf 2007; Betran 2011; Martinez-Galarraga 2012; Ronsse and Rayp 2016; Nikolic 2018; Missiaia 2019). Nonetheless, the application of these models on a relative short period of time limits our understanding how the importance of certain factors increased or decreased over different phases of industrialization. For instance, as the majority of the aforementioned studies (Crafts and Mulatu 2005; Wolf 2007; Martinez-Galarraga 2012; Ronsse and Rayp 2016; Nikolic 2018; Missiaia 2019) have applied the Midelfart-Knarvik et al. (2000) model on the second phase of industrialization, these studies have only limited contributed to the debates on the causes of the Industrial Revolution.

Secondly, and related, did the lack of standardized data inhibit a lack of empirical evidence to test these models in the long run. Although the aforementioned models would potentially be able to identify the explanatory factors for the location of industry, the main reason why these aforementioned studies only applied econometric models on a relatively short period of time can be credited to limitations of data availability. As such, it is no surprise that industrialization has been so often studied on the national level, rather than a lower spatially disaggregated level, which requires a greater deal of standardized data. In addition, regional studies almost exclusively include case studies of one or a few branches of industry in a certain region or city, leaving comparisons across regions difficult to make. Comparable to the national studies, most of these regional studies confront us with problems regarding their use of non-comparable data, often drawing from non-standardized industry classifications or sources that are not available for larger regions, consequently making their studied regions hard to put into an inter-regional perspective.

All in all, a static view on the determinants of industrialization and the fundamental lack of studies which combine long-run standardized data with econometric models are still to blame for our limited knowledge about the long-term drivers of industrialization. By studying the location of industry and the factors driving these patterns during the last two centuries in Belgium and the Netherlands, the aim of our research is twofold. First, we aim to upgrade the available empirical evidence. We set out to create a standardized dataset on industrial employment during the 19th and 20th century, on different levels of spatial aggregation. Of course, a standardization of the data across regions and time is only useful once combined with relevant economic theory and empirical models. Therefore, secondly, we turn to econometric methods, in which we unravel the dynamics in the location of industrial development by reviewing how the location of industry changed in the long-run, during the different episodes of industrialization. In particular, we look at the change in the determinants for the location of industry during the shift from proto-industry to industry, the Industrial Revolution, the second phase of industrialization, and the post-industrial or de-industrial period.

1.3. Scope of the study: the regions in the Low Countries during 1820-2010

We aim to study the location of industry, and its determinants, in the Netherlands and Belgium in the long-run, during the 1820-2010 period. These regions of North-western Europe prove to be a fitting test case to do research on the dynamics of this industrialization process. Not only did both countries follow a divergent path during the Industrial Revolution, with Belgium considered in the historiography as an early follower and the Netherlands as a lagger, also did both countries develop a notable different industry mix during the second phase of industrialization. In addition, both countries present ideal case studies to study regional differences: in Belgium, with the differences between the northern Dutch-speaking and southern French-speaking part of the country, and in the Netherlands, with the differences between the Western economic heartland and the economic more peripheral parts of the country. Of course, when taking a look at the theoretical and empirical contributions on industrialization in the Low Countries, we can come to one conclusion: that much research has already been done. Yet, much alike the debate outlined above about the determinants of the location of industry, often the same determinants - factor endowments, market potential, and institutions - have featured in the debates about industrialization in the Low Countries.

First, a large amount of studies has explored the process of industrialization during the nineteenth century in the Low Countries, in which many studies have debated the causes of the Industrial Revolution. To explain the earlier industrial take-off of Belgium compared to the Netherlands, multiple studies related to factor endowments, in which predominantly the abundant coal reserves in Belgium and the difficult access for the Netherlands to these resources played a pivotal role in many narratives (e.g. Mokyr 1974; Van Houtte 1972; Bos 1979; Griffiths 1979). Similarly, as an example to support his theory on the high wage hypothesis in Britain, Allen (2011: 364) stressed that no other European country as Belgium benefited from a similar wage to energy price ratio comparable to Britain. In addition, market access is often argued to have played a role. Riley (1976) pointed to the role of the efficient transport system in Belgium and Vandenbroeke (1985) stressed the relative high purchasing power in the country, whereas Van Houtte (1972), Bos (1979), and Griffiths (1979) pointed to the role of high transport costs and indirect taxes on coal imports to explain the delayed Dutch industrial take-off. In line with this view, Bogart et al. (2010) argued that the densely populated Low Countries were the only region in Europe with a similar road and waterway density comparable to Britain, which is argued to have contributed to its industrial take-off. Lastly, Lintsen and Steenaard (1991), Davids (1991), 't Hart (1993), and Mokyr (2000) stressed the relevance of institutions, where the political and entrepreneurial class in the Netherlands have argued to lack the necessary impulses to implement technological innovation, whereas the nineteenth century Belgian bourgeoisie is argued to have been more receptive to new forms of entrepreneurship (Polasky 1980).

Second, in the economic history studies that have taken a look at the twentieth century, most notably on the second phase of industrialization, often these same determinants have been stressed. For factor endowments, most notably the relevance of human capital has featured in these debates. For the Netherlands, De Jong (1999) revealed that most notably the high human capital intensive industry sectors experienced growth during the Interbellum. For Belgium, the first half of the twentieth century is argued to have introduced a period of unforeseen human capital investment in the industry sector (Van Meerten 2003). For market potential, for instance, Atzema and Wever (1994) credited the disproportionate industrial growth in the second half of the twentieth century in the Dutch western regions to the higher market potential in these regions. Similarly, Ronsse and Rayp (2016) showed that access to international markets - most notably, the port of Antwerp - has been considered to play a large role in the relocation of many industries from the southern half to the northern half in twentieth century Belgium. For institutions, studies often highlighted the role of public policy. For instance, Buyst (1997) stressed the importance of failed public policy in the downfall of the Walloon steel emporium after the 1950s-1960s, whereas in the Netherlands the rise in industrial employment in the post-war period is often argued to have been the result of a policy of price and wage stabilization (Driehuis and Van den Noord 1980).

Yet, in the aforementioned debates on the causes of the first Industrial Revolution and the second phase of industrialization in both countries, only rarely the regional dimension has featured. Of course, a multitude of studies have explored specific industries in particular regions: notable examples for the Low Countries concern the textile industry in Flanders (e.g. Demasure 2012), the shoe industry in North Brabant (e.g. Van Meeuwen and Mandemakers

1983) or the paper industry in the Zaan area (e.g. Davids 2006). However, only limited studies have contributed to the aforementioned debates about the Industrial Revolution or the second phase of industrialization by providing a systematic account on regional patterns for an entire country. The most notable exceptions have been the works of De Brabander (1983), Buyst (2007) and Ronsse and Rayp (2016) for Belgium and Brugmans (1969), Bos (1976), and Atzema and Wever (1994) for the Netherlands. Yet, amongst these few contributions, only a single exception - Ronsse and Rayp for the 1896 – 1961 period - has contributed to our understanding of the determinants of industrial location.

Similar to the debate about the determinants of industrial location, although the studies on this topic in the Low Countries have contributed significantly to our understanding, the historiography is only able to present us a highly fragmentised view on the determinants of the location of industry in the Low Countries on the long-run. Of course, such a study has been obstructed by a lack of econometric models and datasets. Yet, in recent years, with the increased availability of data, the improved technologies able to process and digitize such data, and the development of econometric techniques, the tools have increasingly become available to formulate a systematic view on the location of industry in the Low Countries. Therefore, this manuscript combines a first standardized dataset on the location of industry with econometric techniques, to study the determinants of the location of industry among the regions in the Netherlands and Belgium during the nineteenth and twentieth century. As such, our study aims to put the aforementioned studies on the determinants of industrial location and the aforementioned studies on the Low Countries in a comparative perspective. For this, the manuscript is limited in two dimensions: a temporal dimension - in which we confine ourselves to the 1820-2010 period - and a geographical dimension – in which we explore patterns of industrialization in the regions of the Low Countries, on different spatial scales.

The temporal scope of our study approximates the 1820-2010 period, roughly encompassing the time frame in which the manufacturing sector went from a handicraft profession to a mechanized and largely automated activity. Rather than opting for time-series data, we chose to collect panel data for several benchmark years. This decision was made based on the assumption that employment numbers did not change drastically over a single year but were rather stagnant over time frames of 10 - 20 years. In other words: we believe these structural changes in the industry sector are ideally studied on the *longue durée*. Therefore, we selected six benchmark years over a time frame of two hundred years (1820, 1850, 1890, 1930, 1970, and 2010), with average gaps of forty years between the chosen benchmark years. The selection of our benchmark years did not follow an arbitrarily chosen starting and end year or a vigorous periodization, rather we made our choice of benchmark years based on a pure practical argument: the availability of sources and data. Therefore, we start our study with the year of 1820, the year in which the first industrial census for the Low Countries was published. The selection of the other benchmark years – 1850, 1890, 1930, 1970, and 2010 – follows largely the publication dates of the population and industrial censuses in the Netherlands and Belgium. The last benchmark year, 2010, matches the most recent year where data was easily retrieved from the national offices of statistics.

The geographical scope of the study covers the Netherlands and Belgium, for which we study the location of industry on different spatial levels. For this, we followed the subdivision of both countries across multiple administrative divisions: the NUTS (*Nomenclature of Territorial Units for Statistics*) levels 1-3, which present a fairly equal number of observations for both countries and which present fairly stable boundaries over time.[1] Yet, in addition, it is possible to break down the collected data on the LAU2 (*Local Administrative Unit*) or municipal level for the 1890-2010 period. On this granular spatial level, we are presented with more difficulties for comparisons over time. In the Netherlands, the number of municipalities reduced gradually during the studied time frame, from 1.236 in 1817 to 431 municipalities in 2010, of which most of the mergers took place during the second half of the twentieth century (Van der Meer and Boonstra 2011). Another situation occurred in Belgium, where 2.739 municipalities in 1830 were reduced to 2.585 municipalities in 1970. Due to a large municipal reform during the 1970s, only 589 municipalities remained in 1977 (De Belder, Vanhaute and Vrielinck 1992), a number that remained constant until 2010. Notwithstanding that the number of municipalities thus changed substantially over the 1820 - 2010 timespan, the geographical boundaries remained more or less constant over time, as the territories of nearly all changed municipalities merged completely within another, making comparisons over time possible by merging the data of each of the historic municipalities to their present-day counterparts.

[1] Two notable changes occurred in the province (NUTS2) boundaries during the period under study. First, both World Wars resulted in an enlargement of the Belgian Liège province and the Dutch provinces along the German-Dutch border. In 1920, Belgium acquired the German departments of Eupen, Malmedy, and Sainkt Vith and the state of Neutral Moresnet, as a compensation for the suffered damage during World War I. This resulted a minor increase of the total population of the Liège province, inflicting a population increase of approx. 33.000 citizens on the total population of 863.000 people in 1930. Second, the annexation of a small number German municipalities by the Dutch government after 1949 altered the surface and population of the provinces of Groningen, Drenthe, Gelderland, Overijssel, and Limburg, which together was responsible for a total population gain of 9.953 people in 1949.

1.4. Main sources and data

To answer our research question, we need a consistent and systematically-constructed dataset. Statistics documenting value added on a detailed sectoral or spatial disaggregated level do not exist in both countries for such a long-term period. Yet, employment numbers in the industry sector are available, thanks to the richly-documented industry censuses, which can be complemented with earlier censuses and recent datasets. In Table 1. we report these main sources which are used continuously in the manuscript.

Table 1. List of the used main sources

	the Netherlands	**Belgium**
1820	Statistics about Dutch industry (1819), collected by Brugmans (1956)	
1850	Condition of the Dutch factories (1859)	Census of industry (1846)
1890	own-constructed database based on municipal reports (1896)	Census of industry (1896), digitized by the Quetelet center
1930	Census of companies (1930)	Census of industry (1937), digitized by the Quetelet center
1970	Census of companies (1978)	Census of industry (1970)
2010	LISA database (2010)	RSZ and RIZIV statistics of the Belgian office of social security (2010)

Most notably, we turned to the industry censuses in both countries, titled census of industry (*Industrietelling* or *Recensement d'Industrie*) for the Belgian editions and census of companies (*Bedrijfstelling*) for the Dutch editions. For Belgium, these censuses are available for the 1850-1970 period. As the first industrial census in the Netherlands was conducted in 1930, we only use the 1930, 1970 and 2010 industry censuses, whereas we had to turn to earlier unofficial censuses which measured employment in the industry sector in the Netherlands on a spatially disaggregated level. For 1850, we could draw upon the published data source condition of the Dutch factories of 1859 (Nederlandse Maatschappij 1859), which measured the industry sector by drawing on a vast collection of municipal reports. As no representative dataset on the industry sector in the Netherlands existed for the turn of the twentieth century, we constructed our own dataset based on archival research, by collecting a large series of local-preserved municipal reports in 1896. To measure employment in industry in Belgium and the Netherlands in 1820, we turned to an industry census constructed under the joint Belgian-Dutch governed

Kingdom of the Netherlands (1815-1839), which has been published by Brugmans (1956). In addition, for the recent period, we turn to government-built official statistics: for the Netherlands, the Dutch LISA register, and for Belgium, the statistics of the Belgian office of social security.

A substantial number of these sources has already been digitized in the last decades. In particular, thanks to the efforts of the LOKSTAT, BELCENS and Quetelet project, the Belgian 1896 and 1937 censuses of industry have already been digitized. For the Netherlands, thanks to the HDNG and NLGIS projects, a fragment of the 1930 census has already been digitized in the past years. Yet, all other sources have been digitized in this study for the first time. Based on these sources, we can reconstruct the number of establishments and employees for the 1820-2010 period and the number of steam engines and steam boilers for the 1820-1930 period across industry sectors and regions in the Low Countries. Yet, in order to make such a consistent dataset, three methodological challenges had to be overcome.

First, for the sake of standardization, we had to settle upon common definitions for our three variables of interest, i.e. the number of establishments, the number of employees, and the value of fixed-asset capital. Overall, for establishments, we collected those data series in the aforementioned industry censuses that measured establishments as "(a part of) a private enterprise where the industrial activity is taking place in which at least a single person is employed". As such, we measure the number of individual establishments where the labour took place rather than the main holding of firms, as large firms with multiple holdings across different places became more common over time and might distort our dataset. In addition, we removed inactive and public establishments. Employees were measured as "the yearly average full time equivalent of people employed in the manufacturing sector, regardless of age or their function in the production process". As such, we corrected in the original data for seasonal and/or part-time employment, a common practice in the pre-industrial and early-industrial period. Lastly, we measured the number of steam engines and steam boilers for the 1820 – 1930 period. For a more detailed explanation on all these definitions, we refer to Appendices C-E.

Second, as we are studying the evolution of industry over time, naturally, the question arises: what is considered industry and which sectors are considered to encapsulate this sector? For this, we decided to strictly follow the definitions of the handbook of the *International Standard Industrial Classification of All Economic Activities* (ISIC), in particular its fourth revision. Given the importance of mining natural resources for the location of industry, most notably coal during the nineteenth century, as such we encapsulate in our analysis the sectors related to mining and quarrying (ISIC divisions 05-09) in addition to the manufacturing sectors (ISIC divisions 10-33). As such, we define industry as both activities related to the mining and quarrying of natural minerals as well as manufacturing activities, understood as the transformation of materials, substances, or components into new products.

We applied these definitions strictly to the used industry censuses. Since the classification systems of industrial sectors differ heavily over these industry censuses, we attributed each census sector to the most-fitting four-digit sector in the ISIC (International Standard Industrial Classification of All Economic Activities) Revision 4 classification, which we collapsed to the two-digit sector division in ISIC. This method holds three advantages. Firstly, this provides us of employment numbers across 29 ISIC two-digit sectors, a relatively large group of sectors when comparing with previous studies on industrialization. Secondly, the ISIC classification presents a consistent classification that builds upon the harmonization of industries based on systemized common characteristics, ideal for our long-run analysis as it leaves little room for misattribution compared to the classification systems in most historical censuses. Thirdly, several industry censuses included obvious non-industrial professions. So, did the 1896 Dutch local municipal reports include data on professions in the tertiary (for instance, shop owners) and primary sector (such as fishermen or lumberjacks), whereas the Belgian 1896 industry census includes occupations related to transportation. The use of the consistent ISIC classification allows us to exclude those professions that do not have a place in any serious study concerning the industry sector. For a more elaborate explanation on this issue, we refer to Appendix B, where we in addition report the correspondence tables from the original census sectors to their most-fitting ISIC sector counterpart.

Third, the earliest industry censuses have oftentimes been credited unrepresentative, as these sources have often been argued to over– and undervalue specific industrial activities. For instance, the first industrial census of Belgium in 1846 excluded data about the household manufacturing, which was widespread in the production of textiles and shoes at that time, while the subsequent censuses of industry did include this type of manufacturing. An additional complication is that several censuses were performed at a problematic timing. So, it has been noted that the Belgian census of 1896 was performed in October, a period in which for instance the sugar manufacturing sector was traditionally performing at full capacity but the ceramic manufacturing sector was hardly active (De Brabander 1984). Likewise, seasonal changes also had a major impact on the measurement of certain industrial sectors, especially those sectors related to food production and construction materials. For instance, the brick laying and producing sector was very poorly represented in the census of 1910 in comparison with the earlier censuses, as the numbers show how the employment in this branch of industry drastically had fallen back due to the hard winter of that year (Buyst 2007).

To resolve these issues, we correct the spatial and sectoral disaggregated data of the industry censuses with the sectoral disaggregated employment data of the population censuses. In contrast to the industry censuses, the population censuses are broader in scope and lists the occupational structure of the entire population, providing thus a representative count of the whole population for all industry sectors. Yet, these population census records have the disadvantage that they do not report these numbers on a spatial disaggregated level. Therefore, we compare the total employment per industry branch from each population census with the ones of each industry census, which not only makes it possible to critically evaluate the representativeness of the industry censuses, but it also enables us to correct for the under –and overvaluation in the industry censuses through a single consistent approach. By multiplying the number of establishments and employees for those sectors where the industrial census didn't report representative numbers, we will thus be able to transform the industrial censuses into a representative dataset. This approach has been used previously for the Belgian industry censuses by Buyst (2007), where it was shown to be fruitful. We correct with this method the industry censuses of 1820, 1850, and 1890. The later industry censuses thereafter we do not correct, as these censuses of the 1930s onwards are considered to have captured more adequately the entire labour force in industry. So, did the industry censuses of 1930 onwards introduce corrections for seasonal and part-time employment (see Appendix C). Moreover, the study of Buyst (2007) revealed that the Belgian industry censuses of 1910 deviated only in minor respect from the total labour force in industry as reported in the population census. For a more elaborate report of this method, we refer to Appendix A.

The presented data and methods allow us for the first time to present a consistent and representative dataset on the number of employees, establishments, and fixed-asset capital in the industry sector. Yet, this does not imply the method is perfect. In particular, this method falls short on two dimensions. First, as we use the employment number per industry branch from the population census to correct the spatial disaggregated employment per industry branch from the industry census, the dataset depends on the assumption that the under –and overvaluations in a particular sector in an industry census occurred proportionally across all regions. Yet – for instance – we can imagine that the occurrence of seasonal and part-time employment was distributed unequal across regions. Second, the industry censuses and the population censuses keep fundamentally different definitions. For instance, the industry censuses exclude Dutch and Belgian citizens working abroad but includes foreigners working in the Low Countries, whereas the population censuses measure both in an opposite fashion. In addition, as the unemployed often gave up their previous held job to the population census takers (Buyst 2007), the population census inevitably overstates the employment in industry. With all these shortcomings in mind, of which this list is incomplete, it is clear that this method of reconstruction is imperfect. Yet, we argue that this method presents the most efficient way to calculate a representative number of employees and establishments on a spatial disaggregated level in both countries, considering the present resources at our disposal.

1.5. Research questions

To structure our main endeavour of tracing back the spatial distribution of the location of industry during the last two centuries, and the factors driving these evolutions, we will address three research questions throughout the manuscript. First, we set out to examine how regional industrial development occurred in these two countries, i.e. how did the location of industry change over time, which sectors clustered over time, and how path-dependent these patterns are. Second, we discuss the theories which explain the changes in the location of industry over time, i.e. was the geographical shift of industry firms influenced by changes in factor endowments, market potential, institutions, or other factors? Third, we question whether these theories or patterns can be adopted universally on both the Netherlands and Belgium, or whether some theories fit some regions or sub-regional entities more than others. Each of these questions will be addressed in the following five chapters. As a preliminary though necessary prelude, we review the long-run trends in the location of industry in the past two hundred years in the Low Countries. In the next four chapters, we review chronologically follow the changes in the location of industry during four different episodes of industrialization: the transition from proto-industry to modern industry, the transition during the first and second Industrial Revolution, the transition during the twentieth century, and the transition occurring in the post-industrial and/or de-industrial period.

In chapter two, we revisit the historiography on the Industrial Revolution and the subsequent phases of (de-) industrialisation in the Netherlands and Belgium, by reviewing the regional trends in industrial development during the 1820-2010 period. Although many studies have studied industrialization in the Netherlands (e.g. De Jonge 1968; Jansen 1999; De Jong

1999) and Belgium (Olyslager 1947; Pluymers 1992; Wautelet 1995), only a limited amount of studies have explored the regional aspect of this process (e.g. De Brabander 1983; Atzema and Wever 2004; Ronsse and Rayp 2016; Buyst 2018). With our dataset, we are able to map many of the patterns that had been put forward in the literature, making us able to put many findings of the literature in a different perspective. As such, we contribute to debates about differences between both countries, such as the earlier take-off of the Industrial Revolution in Belgium compared to the Netherlands or the higher capability of the Netherlands to attract industries in the post-war period. In addition, we are able to quantify notable regional patterns in both countries, such as the relocation of industry in the second half of the twentieth century from the southern to the northern half in Belgium and from the Dutch peripheral provinces to the populous Western regions or *Randstad.*

Chapter three reviews the continuity in the location of industry during the transition from ‘proto-industrial’ activities – understood as the employment in rural, domestic, artisanal production for distant markets taking place within households partly involved in subsistence agriculture – to ‘modern’ or factory-based activities in the 19th century. As such, we provide an empirical test of the literature on proto-industrialization (e.g. Mendels 1972; Kriedte, Medick, and Schlumbohm 1981; Ogilvie and Cerman 1996), which stressed the importance of domestic, labour-intensive spinning and weaving for the development of textiles factories during the Industrial Revolution. So far, the empirical evidence on proto-industrialization has been ambiguous: evidence has shown that some proto-industrial regions did indeed develop into industrial clusters, but many other regions de-industrialized. For instance, Coleman (1983: 442-443) showed that only four out of ten proto-industrial regions developed into regions of modern industry in eighteenth century England. Furthermore, little is known why some regions were more able to develop from proto-industry to modern industry compared to others. Drawing on a large compiled dataset on employment proto-industrial and modern industrial textiles production, we study in a comparative perspective the proto-industrial origins of the two centres of textile manufacturing in both countries during the nineteenth century: north-western Belgium (Flanders) and the eastern Netherlands. Here, we do not only test the continuity or discontinuity in the location of industry during the transition from proto-industrialization to modern industrialization, but also explore the reasons why particular regions were more successful in their transition.

Chapter four traces the regional determinants behind the Industrial Revolution in Belgium and the Netherlands during the first and second Industrial Revolution. Both countries underwent a very divergent evolution in this process: although the Netherlands was in terms of income per capita the richest country in the world at the end of the eighteenth century, it was Belgium which became the second country in the world to industrialize, after Britain, and the Netherlands which underwent an economic standstill during the first half of the nineteenth century. On the causes of the rapid take-off of Belgium compared to the Netherlands, the literature has stressed many factors, amongst which the abundant coal reserves in Belgium, the high wage rate in the Netherlands, the abundance of pre-industrial technology such as wind and water mills in the Netherlands. Yet, human capital, one of the factors which recently received much attention as an explanation for the Industrial Revolution (e.g. Becker et al. 2011; Squicciarini and Voigtländer 2015; Franck and Galor 2018) has hardly featured in the historiography of both countries. In order to address these debates, in this chapter, we set out to explain the number of steam engines per sector and per region during the first and second Industrial Revolution with the regional distribution of human capital and other factors stressed as causal in the literature.

Chapter five identifies the macro-economic factors which determined the location of industry during 1890 – 1970 in the Netherlands and Belgium, as well as the NUTS1 regions in both countries. By making use of an adjusted version of the Midelfarth-Knarvik model, we empirically test the theoretical implications of the Heckscher-Ohlin theorem – which stresses the relevance of factor endowments – and the New Geography theory – which stresses access to domestic and international markets – for the determinants of industrial location. This model has been used previously for a larger number of countries during short periods of time, such as Britain during 1871-1931 (Crafts and Mulatu 2005), Poland during 1902–1937 (Wolf 2007), Spain during 1856-1929 (Martinez-Galarraga 2012), USA during 1880-1920 (Klein and Crafts 2012), Belgium during 1896-1961 (Ronsse and Rayp 2016), Yugoslavia during 1932-1939 (Nikolic 2018), and Italy during 1871-1911 (Missiaia 2019). Yet, besides the consensus that both factor endowments and market potential can explain the location of industry, not much has been concluded from the literature. So did the non-negligible variability in both data and methodology (Rayp and Ronsse 2019), with all contributions evaluating the determinants of industrial location in one country during a brief period of time that predominantly featured the period at the end of the nineteenth century and the beginning of the twentieth century, hinder comparisons over countries and time. With this chapter, we contribute to this stream of literature in two respects. First, we test for the determinants over a longer period of time, in 1890, 1930, and 1970, therefore making it possible to test the relative weight of factor endowments and new economic geography factors on the longue durée. Second, by drawing on data on a detailed geographical level – the LAU2 or municipal level – in both countries, we are able to explore both inter-country and intra-country differences in the determinants of industrial location.

Chapter six studies which regions suffered most from the disappearance of manufacturing jobs in Belgium and the Netherlands, and explores the long-term reasons why these regions were more burdened with costs of de-industrialization. Notable debates have arisen in the field of economic geography and economic history about how and why once-flourishing industrial districts such as the Great Lakes region in the USA or the Ruhr area in Germany have experienced a reversal of fortune in the face of de-industrialization. Yet, in the literature on these so-called rust belts, two causes are often invoked that trace the causes of de-industrialization back before the period of de-industrialization. On the one hand, studies have argued that a long-term presence of industrial activities, which often predominantly encompassed low-skill intensive sectors, hindered human capital accumulation in those regions (e.g. Franck and Galor 2018). On the other hand, studies argued that the high level of specialization in the economic structure exposed these rust belts to external shocks, when these sectors would eventually relocate and automate after the 1960s. To address this debate, we follow a two-step approach. First, we introduce an unbiased classification strategy to identify which municipalities in the Netherlands and Belgium experienced a negative effect due to de-industrialization during 1970-2010. Second, in order to identify the long-run causes of resilience against de-industrialization, we study how these non-resilient regions differed from the municipalities which were resilient against de-industrialization during the 1850-2010 period.

Finally, in chapter seven, we present a brief conclusion in which we review shortly the main findings of the previous chapters on the long-run patterns of regional development, how the drivers of industry change over time, sectors and regions, and what the possible avenues of further research and policy implications are that we can draw from this research.

Chapter 2. Long-run trends in the location of industry in the Low Countries

(together with Erik Buyst)[2]

2.1. Introduction: historiography on the location of industry in the Low Countries

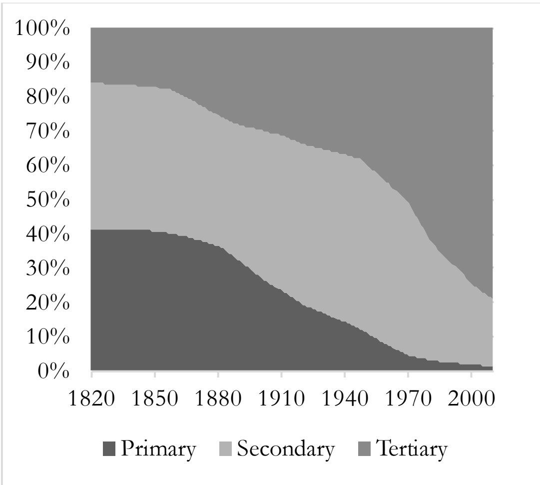
In 1815, the Congress of Vienna amalgamated both the Netherlands and Belgium into one state, the United Kingdom of the Netherlands. Both areas had quite a different backstory, however, which eventually contributed to the Belgian secession in 1830. The Netherlands inherited an advanced economy from the Dutch Golden Age of the 17th century: in per capita income, it was only surpassed by Britain. Belgium, on the contrary, recovered only slowly from the devastations of the wars of Louis XIV. At the beginning of the 19th century, gross domestic product per capita in Belgium was about one third lower than that of its northern neighbour. Nevertheless, it was Belgium that became the second industrialiser after Britain, while the Netherlands fell behind its southern neighbour for the rest of the nineteenth century (Mokyr 1976). To a certain extent, the publications in the Low Countries over the last decades reflect the relative importance of the Industrial Revolution in both countries: whereas the industry sector in Belgium has been the subject of many monographs (e.g. Olyslager 1947; De Brabander 1983, 1984; Pluymers 1992; Wautelet 1995), publications in the Netherlands are somewhat less abundant (e.g. De Jonge 1968; Jansen 1999; De Jong 1999).

If we compare the employment structure of Belgium and the Netherlands (see figure 1), we immediately notice that industrial activities continued to take a relatively larger share in the economy of Belgium than the Netherlands, throughout the 1820-2010 period, although the Netherlands overtook Belgium in absolute employment numbers during the 1990’s. Instead, the labour structure in the Netherlands focused more on commerce, a tradition they had held since the early modern period, and agriculture: most prominently dairy (De Jong and Van

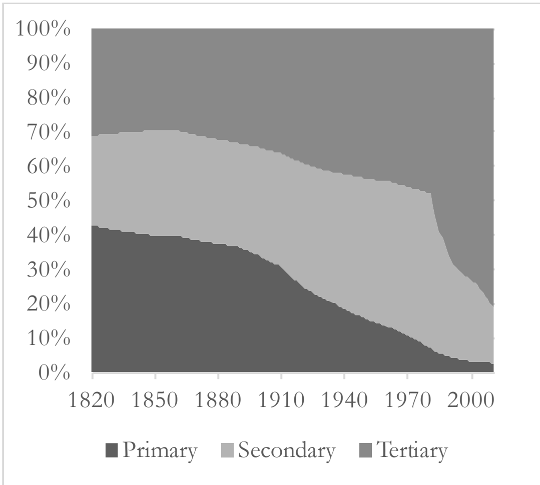
[2] This chapter is largely based upon the following working paper: Philips, R. and Buyst, E. “Long-Run Trends in the Location of Industry in the Netherlands and Belgium (1820-2010)”. Therefore, we thank the Historical Database of Local and Cadastral Statistics LOKSTAT-POPPKAD (Quetelet Center, Ghent University) and Sven Vrielinck for providing data, as well as the participants of the 2019 Posthumus Conference and Matthijs Degraeve, Erik Vanhaute, Bas van Leeuwen, Jan-Luiten van Zanden, and Jop Woltjer, for their well-appreciated suggestions.

Zanden 2014: 95-96). In contrast, the Belgian labour structure started out with a significant larger industry sector in 1820 due to its strong focus on mining and textiles production. Nonetheless, both the Netherlands and Belgium experienced increasing employment in industry during the nineteenth century, continuing in the first half of the twentieth century, a period in which the Netherlands saw the rapid expansion of its industry base. An absolute peak was reached in the 1950's for Belgium and the 1960's for the Netherlands, followed by a de-industrialisation process that continues even today.

Figure 1. Employment in Belgium and the Netherlands, by sector (1820 – 2010)[3]



Belgium



the Netherlands

Although these national patterns of industrialisation have been thoroughly studied (e.g. Olyslager 1947; De Jonge 1968; Pluymers 1992; Wautelet 1995; Jansen 1999; De Jong 1999), this is far less the case for the regional dimension (e.g. De Brabander 1983, 1984). Yet, starting in the 1980's, scholars started stressing that the rate and timing of industrialisation did not only differ between countries, but even more across regions within the same country. For instance, Patrick O'Brien (1986, 297) argued that "industrialisation […] was a regional and not a national process," and Sidney Pollard (1981, VII) noted that "this [industrialisation] process is essentially one of regions." Subsequently, since the late 1990's, spatial patterns have increasingly come to the forefront in studies on industrialisation (e.g. Kim 1995; Crafts and Mulatu 2005; Missiaia 2019). Notwithstanding this change to the international research agenda,

[3] Sources: for Belgium, we used the Population Censuses of 1846 – 1991, supplemented with the labour structure in 1819 as estimated by Buyst (2018) and the statistics of the Federal Planning Bureau for 2001 and 2011. For the Netherlands, we used the CBS publication '200-jaar-statistiek-in-tijdreeksen'.

a systematic account of the location of industry throughout the nineteenth and twentieth century has been lacking for the Low Countries. Nonetheless, anecdotal evidence about the relevance of these regional processes exists. In Belgium, the social and political alienation between the northern Dutch-speaking and southern French-speaking population poses an important friction in the country. Similarly, in the Netherlands, the view that the Dutch western regions or *Randstad* benefit disproportionally from political attention is a popular and longstanding belief.

Therefore, we explore the regional dimension behind industrialisation in both countries. For long, such an exploration was hindered by the absence of a standardised dataset for both countries. Therefore, we draw upon a recently-constructed standardised dataset (Philips 2019), which allows us to reconstruct the location of industrial activities on the provincial or NUTS2 level (*Nomenclature of Territorial Units for Statistics*) for the 1820-1850 period and the municipal or LAU2 (*Local Administrative Units*) level for the 1850-2010 period. We do not exclusively look at the manufacturing sectors, defined as sectors 10 – 33 in the ISIC (*International Standard Industrial Classification of All Economic Activities*) classification, but – due to the frequently stressed importance of coal and other natural resources in the early industrialisation process (e.g. Allen 2009, Wrigley 2010) – also the mining and quarrying sectors, encompassing sectors 05 – 09 in the ISIC classification. In section 2, we briefly present the aggregate trends in industrialization in both countries, in which we differentiate across three time periods.

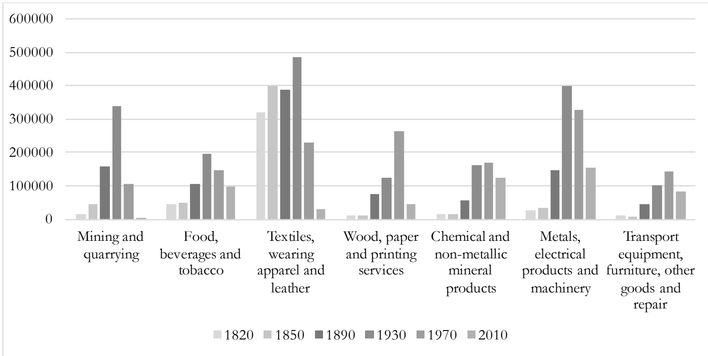
In addition, we explore the evolutions in the location of industry in a more analytical perspective, by reviewing the patterns of regional specialization in the Netherlands and Belgium and measure how these patterns are path-dependent or reproduced over time. Ever since Alfred Marshall (1890: 271) noted that ‘when an industry has thus chosen a locality for itself, it is likely to stay there long’, the continuity in the location of industry has spurred the interest of economists, historians, and economic geographers. The introduction of the concept of path dependence by David (1985; 2007) and Arthur (1989; 1994) in turn attracted the interest in New Economic Geography studies, with Paul Krugman (1991: 80) hypothesizing that ‘if there is one single area of economics in which path-dependence is unmistakable, it is in economic geography - the location of production in space’. Often, the likelihood of path dependency increases by a high level of regional specialization, as a lack of diversification in a particular region raises the probability of an old industrial area becoming ‘locked-in’, unable to develop new growth paths (e.g. Grabher 2007; Hassink 2005). Recently, this topic regained attention, both in the fields of evolutionary economic geography (e.g. Martin and Sunley 2006; Boschma and Frenken 2007; Boschma and Martin 2010) and new economic history (e.g. Crafts and Wolf 2014; Nikolic 2018). Nevertheless, few studies have empirically measured regional specialization and path dependence in the location of economic activities over the long run. Therefore, our evidence on the Netherlands and Belgium can contribute to these debates, in which we continue with patterns of regional specialization and path dependence in Sections 3 and 4. Finally, we end with a brief conclusion in section 5.

2.2. Aggregate patterns in the location of industry

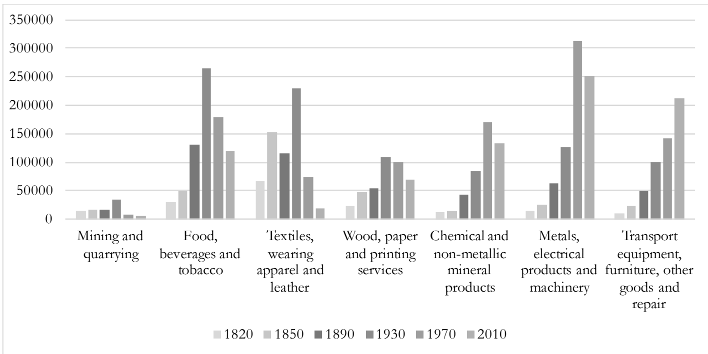
In 1820, based on figure 2, both countries started with a significantly different industry mix before the Industrial Revolution broke out. The Netherlands inherited from its 17th-century Golden Age an advanced and highly diversified economy, with a broad industry mix, oriented towards its trade facilities to import commodities from abroad and export processed products played an important role (Van Zanden and Van Riel 2004). Most notably, shipbuilding, tobacco processing, and foodstuffs such as sugar and grain benefitted. Conversely, the production of textiles and wearing apparel dominated the industry mix in Belgium, depending heavily on small-scale linen sweatshops and domestic-grown flax production (Vandenbroeke 1979). With the Industrial Revolution, mining of coal and iron ore grew exponentially in Belgium, providing the inputs for the production of basic metals and finished goods, such as mechanic pumps and steam engines.

During the nineteenth and early twentieth century, although both countries embarked on a dazzling process of technological progress and labour productivity increases, the more 'traditional' sectors continued to dominate the industry mix in both countries. So, did foodstuffs production in the Netherlands and the production of coal and metal goods in Belgium remain the largest sectors. After the mid twentieth century, the 'traditional' textiles and metal industries were hit by a process of automation and delocalization, first to other regions within Europe and later to other regions in the world. Belgium was hit the hardest by the de-industrialization process, with its larger manufacturing base and its focus on mining and textiles production. Simultaneously, an influx of new manufacturing activities occurred, with increasing production in electrical equipment, rubber and plastics. Whereas Belgium specialized relatively more in the production of motor vehicles, pharmaceuticals, and chemicals, while the Netherlands specialized in the production of computers, machinery and other equipment. In this process, the Netherlands proved more able to attract these new manufacturing sectors compared to Belgium, in part due to the growth of several large Dutch multinationals, as well as a strong government-led policy of industrial expansion during the 1950s and 1960s (Atzema and Wever 1994).

Figure 2. Employment in Belgium and the Netherlands, by mining and manufacturing sectors



Belgium



the Netherlands

Yet, when looking at the distribution of industrial activities on the macro-regional level (NUTS1 level) in table 2, we find that this rudimentary evidence already highlights substantial differences across regions. In Belgium, the balance shifted from the northern, Flemish side to the southern Walloon side during the 1820-1930 period. After 1930, due to the closure of the coal mines and a relocation of many metal factories out of Wallonia, we see the balance shifting back to its northern half, although the entire country suffered heavily from de-industrialisation. In the Netherlands, we notice a more stable pattern, in which the western regions - the most urbanised, prosperous part of the country since the early modern times (e.g. De Vries 1974) - encompassed the Dutch industrial heartland. However, a reversal of fortune took place among the more peripheral regions, with the northern regions losing ground during the nineteenth century, and afterwards a similar pattern of relative decline unfolding in the eastern part of the country.

Table 2. Employment in the mining and manufacturing sectors in Belgium and the Netherlands, over macro-regions (NUTS1)

	1820	1850	1890	1930	1970	2010
Flanders	326.764	324.083	357.986	718.287	790.328	336.415
Brussels-Capital[4]	10.177	29.501	110.474	287.749	230.100	84.567
Wallonia	112.496	214.482	515.794	803.052	363.079	120.525
Belgium	**449.437**	**568.066**	**984.254**	**1.809.088**	**1.383.507**	**541.507**
Northern Netherlands	31.041	65.961	37.759	118.589	99.936	93.585
Eastern Netherlands	32.608	57.585	90.922	185.350	193.552	184.491
Southern Netherlands	29.484	58.922	101.434	188.228	284.231	254.130
Western Netherlands	80.066	148.762	242.867	457.958	408.199	278.206
the Netherlands	**173.199**	**331.230**	**472.982**	**950.125**	**985.918**	**810.412**

In order to study these regional patterns in greater detail, we differentiate in the next three sections across three time periods: the Industrial Revolution (1820-1870), a phase of industrial maturity (1870-1960), and the post-industrial phase (1960-2010).

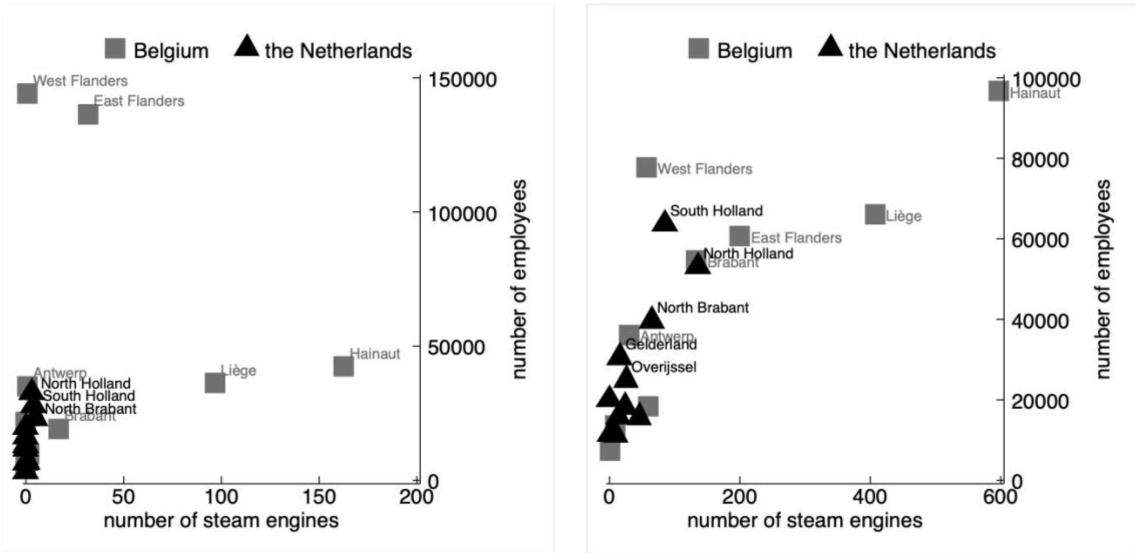
2.2.1. Aggregate patterns during the Industrial Revolution (1820 – 1870)

In 1820, we find that Belgium had already taken a substantial lead over the Netherlands in terms of industrialisation (see table 2). Likewise, in terms of steam engines, Belgium counted 313 steam engines in the mining and manufacturing sectors in 1820, whereas merely 13 steam engines were installed in the Netherlands. Following the studies of Mokyr (1974; 1976), many scholars used the comparison of early industrialising Belgium and the ‘industrial retardation’ in the Netherlands (Griffiths 1979) to investigate the causes of the Industrial Revolution (e.g. Bos 1979; Lintsen and Steenaard 1991). However, based on figure 3, one might wonder whether this juxtaposition is correct. Both in employment as in number of steam engines, the Belgian lead in 1820 had a significant regional component. It was not Belgium in its totality where mechanisation had taken place by 1820. Rather, this process seems to have been confined to a much smaller geographical area, the Hainaut and Liège provinces - which not surprisingly covers those regions in the Low Countries equipped with coal reserves -, where almost 80% of

[4] As the industry census of 1820 only reported the location of industry on the NUTS2 region of Brabant (which is subdivided partly over the NUTS1 regions of Flanders, Wallonia, and the Brussels-Capital region), we used the 1850 distribution of the employment in the Brabant province over the three NUTS1 regions (32.69 % for Flanders, 53.51 % for Brussels-Capital and 13.80% for Wallonia) to subdivide the 1820 employment number of Brabant.

all steam engines in the Low Countries had been installed by 1820, thus not only far surpassing all Dutch provinces but the other provinces in Belgium as well. By 1850, a catching-up process had started in terms of steam engines, with the Belgian provinces of East Flanders and Brabant and the Dutch provinces of North Holland and South Holland catching up with the Hainaut and Liège provinces.

Figure 3. Employment and steam engines in Belgium and the Netherlands, in 1820-1850

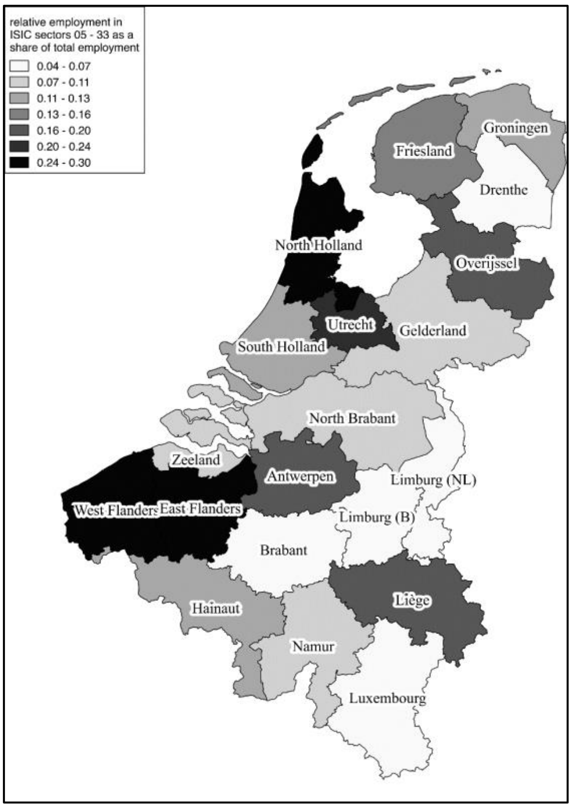


1820 **1850**

Notwithstanding that by 1820 the Industrial Revolution had already kicked off in the Liège and Hainaut provinces, based on figure 4 it appears that this did not fundamentally challenge the pre-industrial geographical distribution of employment in industry (yet). In absolute employment numbers, 45% of the employment in industry in the Low Countries was located in the Belgian East and West Flanders provinces, where the widespread textiles industry dominated the picture. Next to these two Belgian provinces, the other Belgian and Dutch regions were on a relative par at the beginning of the nineteenth century in terms of employment numbers in industry. Here, the more populated North Holland, South Holland, Utrecht, Antwerp and Liège regions were the forerunners, although the gap with the other regions remained relatively small.

At the beginning of the 19th century, East and West Flanders were dominated by employment in the age-old rural linen industry. Its value added per worker however is considered small compared to that of factory production and therefore the importance of the rural linen industry is frequently overlooked in Belgian historiography.[5] Additionally, East Flanders developed considerable factory production in cotton textiles in the city of Ghent, where Lieven Bauwens smuggled machinery out of England in the 1790s to set up the first mechanised cotton spinning mill. Soon, other entrepreneurs followed his example, and the city counted approximately 10,000 factory workers by 1812 (Périer 1885).

Figure 4. Employment in mining and manufacturing sectors in Belgium and the Netherlands in 1819, as a percentage of the labour force



However, most modern factory production in 1820 could be found in the Liège and Hainaut provinces. The English emigrant technician William Cockerill started the production of the first modern water-driven carding and woollen spinning machines in Verviers (Lebrun 1948). The net creation of jobs should not be exaggerated: often, this new factory labour simply replaced homeworkers in the surrounding countryside (Servais 1982). However, it was William's youngest son, John Cockerill, who added a spectacular dimension to the industrial

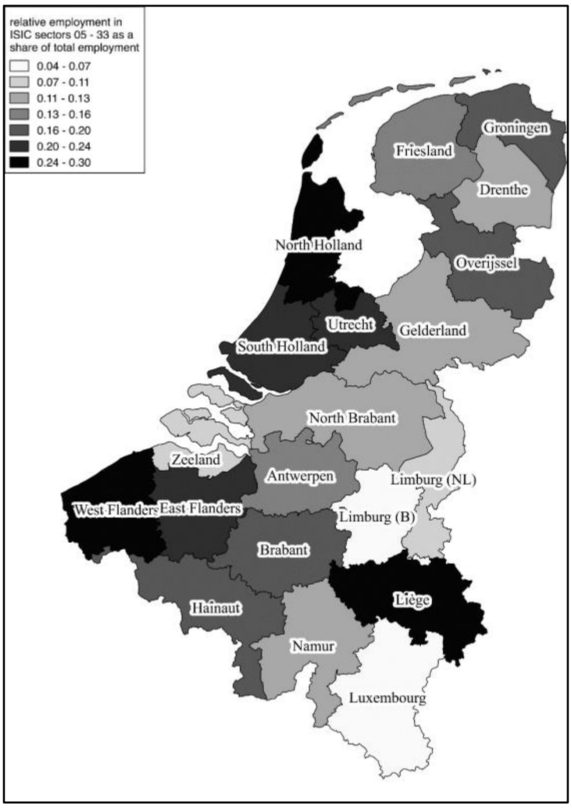
[5] For instance, De Brabander (1981) estimated that in 1846 only 32,000 full-time workers in textiles were active in the West Flanders province. Instead, an official count of 1843 – when the heydays of the linen sector were already over – registered about 150,000 linen workers in West Flanders, and 62% of them considered the linen industry as their main occupation (Moniteur Belge 1846).

revolution in this region. He quickly diversified output, by starting the production of hydraulic presses, pumps, and steam engines in Seraing, building the first blast furnace operating on coke in continental Europe, and exploiting coal and iron ore mines (Veraghtert 1981). In the Hainaut province, a major centre of metallurgy emerged around Charleroi in the 1820's. At this occasion, the latest British techniques were introduced, such as the puddling process and coke furnaces (Lebrun et al. 1981). Additionally, the breakthrough of cokes over charcoal as fuel drastically changed the localisation of the iron industry. While the abundance of wood and the presence of iron ore had for centuries lured the iron industry to the provinces of Luxembourg and Namur, after the introduction of coke furnaces the coal producing provinces of Hainaut and Liège became the new places to be.

In the Netherlands, most industrial activities in 1820 were located in the province of North Holland, where industry relied heavily on the inheritance of the 17th century Dutch Golden Age. In particular, Amsterdam and its trade facilities were crucial for importing commodities from abroad and exporting thereafter the finished products: Baltic grain imports for the Dutch gin (the so-called *jenever*) distilleries and beer breweries, Dutch overseas colonies for tobacco processing and sugar refining activities (Van Zanden and Van Riel 2004), parallel to growth in shipbuilding and supporting industries. Meanwhile, the relatively high living standard in the western cities sparked retail-oriented industries, with for example, notable production in bread, glass, and domestic iron appliances in Utrecht. Furthermore, we find several regional clusters in the west, such as paper milling in the Zaan area (Davids 2006), textile industry in Haarlem, and ship construction in Den Helder.

Meanwhile, the more peripheral part of the Netherlands was characterised by a great deal of specialisation, in part based on sales to the urbanised, western part of the country. In the east of the country, we find notable textiles production in the Twente and Achterhoek countryside, for which Holland and neighbouring Germany acted as both local suppliers of flax and their main consumer markets (Hendrickx 1993). In the Dutch north, we find substantial employment in peat extraction and processing of agricultural products such as butter and cheese. Although the former is largely associated with the heydays of the Dutch Republic, consumption of this energy source rose during the 19th century, for the brick, tile, and bakery product factories as well as the household consumption (Gerding 1995).

Figure 5. Employment in mining and manufacturing sectors in Belgium and the Netherlands in 1846/1859, as a percentage of the labour force (province level)



By 1850, we encounter substantial changes in the location of industry, partly attributable to the economic policies of Willem I during the United Kingdom of the Netherlands (1815 – 1830) and the subsequent split between both countries. Willem's reforms targeted economic integration in his kingdom, by stimulating the already-existent industry in the south with the establishment of a new bank, the *General Dutch Company for the Promotion of Public Industry* (*Algemeen Nederlandsche Maatschappij ter Begunstiging van de Volksvlijt*) and trade in the northern part with the establishment of the *Netherlands Trading Society (Nederlandsche Handelmaatschappij*) a de facto successor of the *Dutch East India Company*. Although these institutions succeeded in accelerating growth in the Southern Belgian regions (see figures 4 and 5), they have been argued to hinder the development of a Dutch industry sector (Van Zanden 1996, 84).

The break-up between both countries was most felt in the largest industry sector of both countries, the production of textiles. For instance, the *Netherlands Trading Society* initially bought almost exclusively textiles from Ghent for sale in Indonesia. After 1830 the *Society* turned to Dutch textile producers, benefitting the new textiles centres in Overijssel and

Gelderland and the old textiles cities of Tilburg, Haarlem, Leiden, and Amsterdam. Moreover, with the Indonesian cultivation system in place, the supply of colonial commodities soared to the benefit of sugar refining, tobacco processing, and coffee branding activities in the Netherlands. Similarly, ship construction flourished along the Holland coastline, putting increasingly more pressure on the smaller shipyards in Zeeland, Friesland, and Groningen (Jansen 1999).

On the losing side, we find the rural linen industry in the Belgian provinces of East and West Flanders. First, the region suffered from the growing popularity of cotton cloth and from the quick mechanisation of British flax spinning after the 1820s (Vandenbroeke 1979; Hendrickx 1993). A deep crisis followed during the years 1845-1847, when the potato blight and harvest failures caused a famine (Rapport 1846). Yet, figure 5 does not fully reflect this decline in employment, as unemployed people often mentioned their previous occupation to the census officials, in which case figure 5 could potentially even show an overvaluation of employment in manufacturing. Meanwhile, the export-oriented Ghent factory cotton industry took a blow when access to the Dutch East Indies was closed in 1830, causing some of the Ghent textile barons to even migrate to the Netherlands (Mokyr 1976).

In contrast, the Hainaut and Liège provinces, and to a lesser degree the adjacent Namur and Luxembourg provinces, grew rapidly in Belgium. The railway boom, which started in the mid-1830's, gave coal mining and metal processing another powerful boost. In Liège, the construction of locomotives and other railway equipment soared. Benefitting from cheap inputs, many other energy-intensive sectors arose alongside the Belgian coal belt. So did the glass working industry flourish, with the establishment of the Val Saint Lambert factory in Seraing in 1826 and Petrus Regout's glass grinding company in Maastricht in 1834, which eventually culminated in his conglomerate of nails, pottery, and guns.

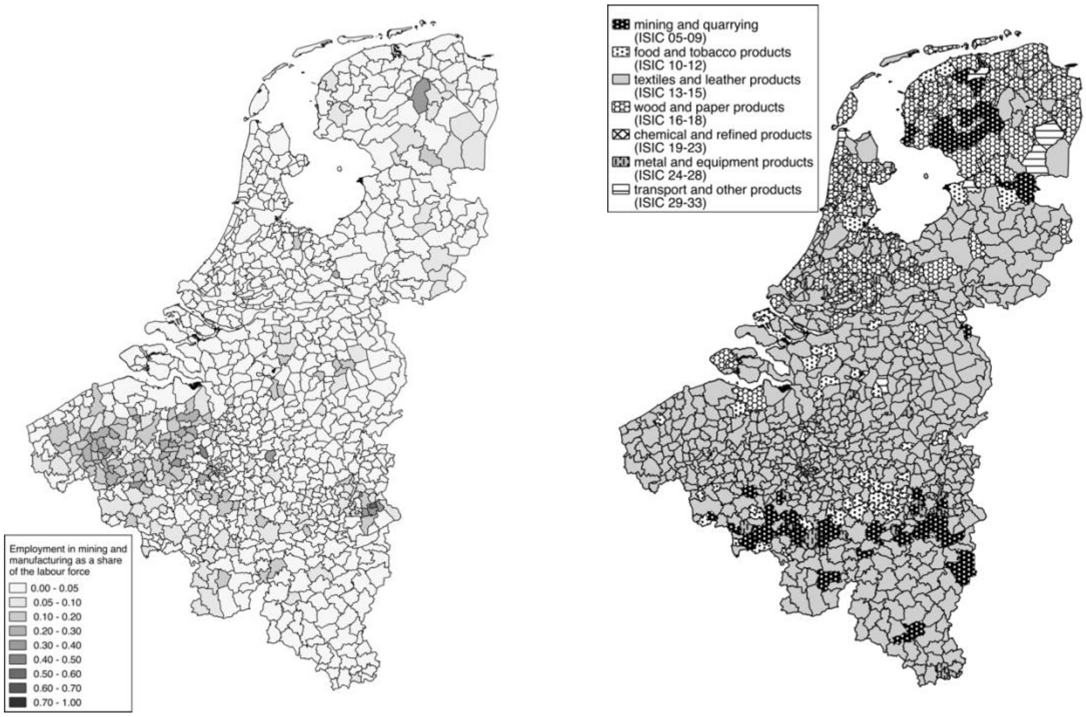
As direct followers in terms of the steam engine installation, we find the South Holland and Brabant provinces (see figure 3). In these regions, more retail-oriented industries arose, benefitting from the proximity to large consumer markets such as the cities of Rotterdam and Brussels, with the opening of the first starch factory in Gouda in 1819 and the sugar refinery in Tienen in 1836. Meanwhile, the peripheral provinces of Dutch Zeeland and Belgian Limburg lost ground. The Northern Netherlands faced a relative standstill as well, with many smaller, low-productive handicraft producers able to withstand increasing competition during the first half of the nineteenth century (De Jonge 1968). One illustrative example is the northern peat extraction sites which benefitted from increasing domestic demand, as a result of a temporal vacuum created by the installation of an excise in 1830 on imported coal from Germany and Belgium (Van Zanden and Van Riel 2004) and the nearly-emptied peat bogs in the Dutch south (Gerding 1995).

2.2.2. Aggregate patterns during the phase of industrial maturity (1870 – 1960)

In 1850, we find a relatively equal distribution of manufacturing activities across both countries (see figure 6). In most of these municipalities, the production of textiles and leather was by far the largest manufacturing sector. Nonetheless, high employment numbers are found in East and West Flanders, where many families still participated in domestic textiles activities, just as in the regional clusters surrounding the cities of Liège, Charleroi, Groningen, Tilburg, and Eindhoven. Other examples of regional specialisation include mining and quarrying in the Belgian south, peat cutting in the Dutch north, and food producing clusters in Holland and Brabant. By 1890 (see figure 7), we find that clustering has been taken to another level. By this time, mechanisation extended from the pioneering industrialising sectors, such as mining and textiles, to newly-mechanised industries, such as metallurgy and more retail-oriented industries. Furthermore, in figure 7, we find that Belgium focused more on heavy, energy-intensive industries such as metallurgy and chemicals, whereas the Netherlands relied more on light industries, including foodstuffs, beverages, and tobacco production.

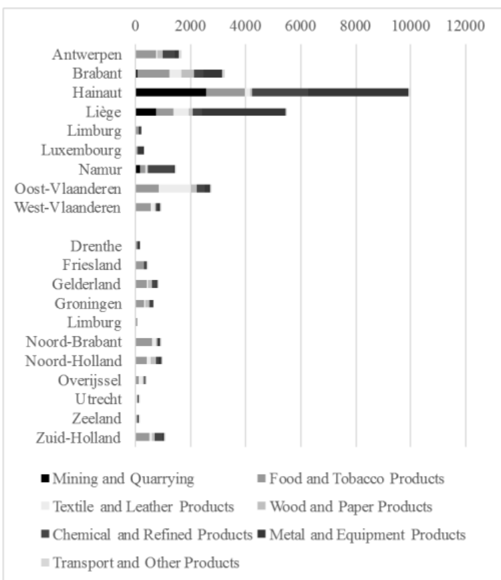
Although the railway boom had already taken off in the Low Countries during the 1830's, railway construction would peak during the 1860's – 1870's. Additionally, from the second half of the 1870's, a transition took place from iron to steel production, after which the output of steam engines, locomotives and other railway equipment soared, most notably in the Hainaut-Liège region. The other decisive location factor for metallurgy, water, benefitted this region as well. By 1890 a fully-connected industrial axis or *Sillon Industriel* was formed alongside the Sambre and Meuse rivers. In the Netherlands, changes in the metallurgy sector impacted less its economic geography, although clusters arose around the Ijssel river which had direct access to coal from the Ruhr area (Smit and Straalen 2007) and the outskirts of Amsterdam alongside the Amstel river (Van Zanden 1987).

Figure 6. Employment in mining and manufacturing sectors in Belgium and the Netherlands in 1846/1859, as a percentage of the labour force (municipality level)



employment in industry (as a percentage of the labour force) — largest manufacturing sector within region

Figure 7. Steam engines in mining and manufacturing sectors in Belgium and the Netherlands in 1896

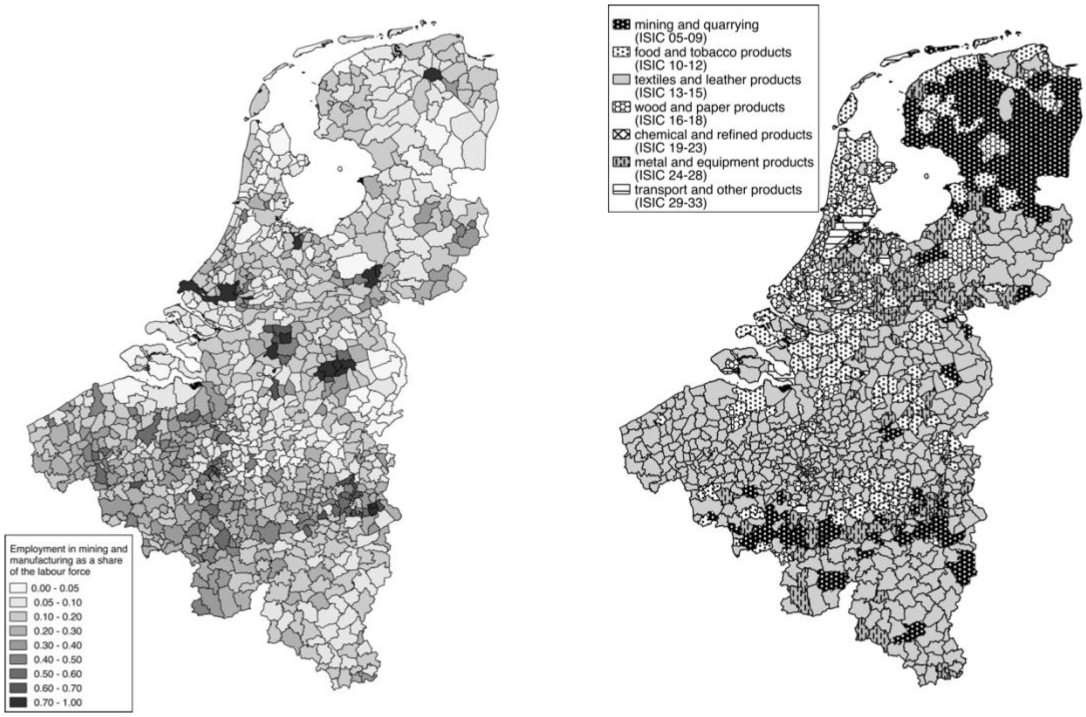


The economic geography in the Netherlands changed considerably more by the scaling-up of another sector during the 1870's – 1890's: food processing. A well-documented example is the production of butter, for which the consumer revolution in domestic and international markets during the second half of the nineteenth century stimulated the demand for inferior but large quantities of butter (Jansen 1999). Local producers in North Brabant jumped into this market, because they had access via the Maas river not only to the port of Rotterdam, but to the English and German markets as well. Soon, two local merchants - Van der Bergh and Jurgens in Oss - became the largest traders in butter in the world (Atzema and Wever 1994). Eventually, both developed artificial butter which circumvented costly and hard-to-get dairy inputs, setting up business together in Rotterdam, establishing the Unilever company in 1929. Similar clusters arose for sugar refining in North and South Holland, tobacco production in South Holland and North Brabant, spirits and alcoholic beverages in South Holland, and potato starch in Groningen.

What happened to the metal processing and food producing sectors was the reverse to what the textiles and leather producing sectors endured. In East and West Flanders, the unequal battle between hand and mechanised textiles production finally came to a close. First, rural flax spinning vanished from the economic scene in the 1850's and 1860's; a sector that had employed about 150,000 workers in the region in 1843 (Moniteur Belge 1846). In the 1870's, the same happened with rural flax weaving, causing many workers in West and East Flanders to return to agriculture or take up a part-time job in lace production, shoemaking, and other sweat shop activities (Verhaegen 1961). However, just as in figure 5, this is not entirely reflected in figure 6, as many of the unemployed stated their former or part-time occupation in the 1896 census.[6] In contrast, mechanised textiles production flourished in other parts of Flanders, although these activities were located in other sub-regions than the former linen heartland. Thus, the traditional centres of Tielt, Torhout, and Geraardsbergen went into decline, whereas mechanised production flourished in the cities of Ghent, Aalst, and Sint-Niklaas.

[6] So did 25,547 women in West-Flanders and 18,016 women in East Flanders state lace production (*kantklosters)* as their occupation in the census of industry of 1896, although this occupation was most likely a part-time job for these women.

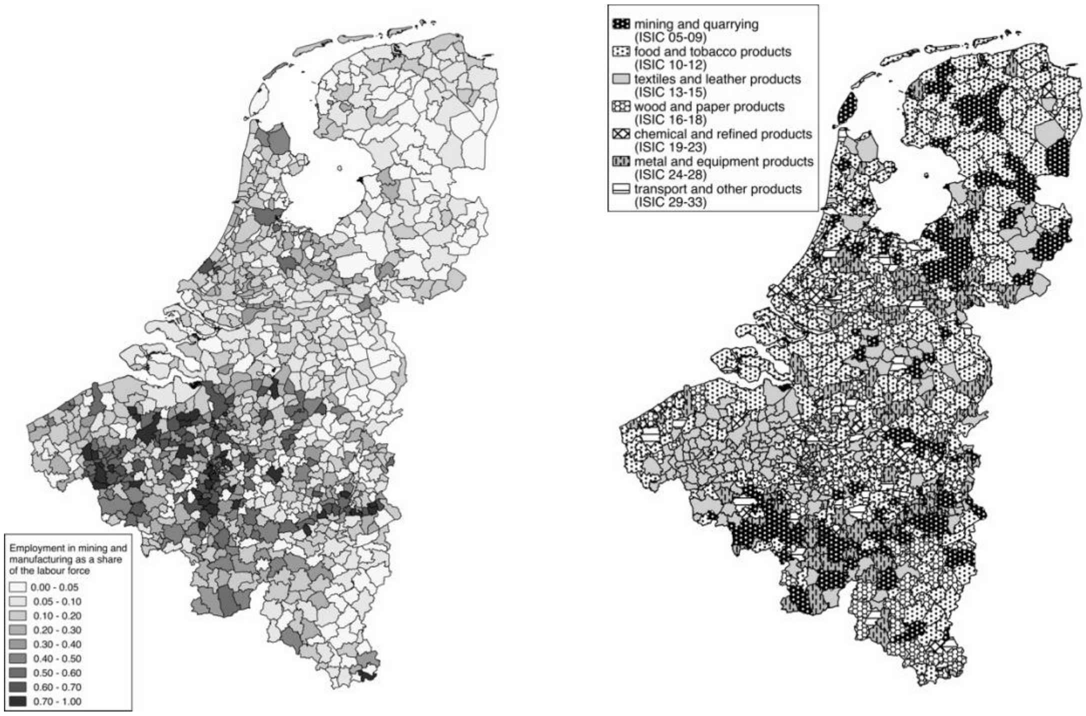
Figure 8. Employment in mining and manufacturing sectors in Belgium and the Netherlands in 1896, as a percentage of the labour force



employment in industry (as a percentage of the labour force) | largest manufacturing sector within region

In the Netherlands, we find a similar pattern of flourishing and declining industrial clusters. Here, textiles clusters emerged in the east and south of the country - Tilburg, Enschede, Helmond, Hengelo, and Almelo - where the concentration of industries went hand in hand with the formation of new urbanised centres. In contrast, many smaller manufacturing firms continued to co-exist in the Dutch northern provinces throughout the 1850 - 1870 period. However, when the Dutch mechanisation process caught fire during the 1870-1910 period and an agricultural crisis took place during the 1880's (De Jonge 1968), many of these northern industry workers were inevitably driven out of their traditional jobs. Soon, it became clear that the northern peripheral provinces had missed the boat towards industrialisation and the formation of new urbanised centres, in contrast to the Dutch eastern and southern periphery (Atzema and Wever 1994). For the inhabitants of these regions, one of the escape routes from poverty was migration to the Dutch west. Another one was to look for the few job opportunities available in the industrial sectors of the region, such as the few peat fields which remained profitable (most notably in Drenthe, where peat extraction even increased during the second half of the nineteenth century),[7] or in the sectors dependable upon agricultural inputs such as the dairy factories in Friesland or straw paperboard and potato starch factories in Groningen.

Figure 9. Employment in mining and manufacturing sectors in Belgium and the Netherlands in 1930/1937, as a percentage of the labour force



employment in industry (as a percentage of the labour force) | largest manufacturing sector within region

An exogenous shock to the industry sector occurred with the first World War and its aftermath, which impacted both countries in a very different way. Although the main battles happened outside its manufacturing belts, Belgian machinery and equipment fell prey to German policies of dismantlement, plunder and deliberate destruction. On the other hand, Dutch neutrality during the war stimulated import substitution policies to replace former imports from belligerents such as Belgium and Germany. However, in the 1920's and 1930's, the economies of Belgium and the Netherlands drifted even further apart. Although

[7] The measurement of employment in peat extraction is heavily complicated, due to the high seasonal variation and the annual variation related to the exhaustion of peat fields. Nonetheless, taking the Drenthe province as an example, our results indicate an increase of 1,447 to 5,542 full-time equivalent employees during 1820-1890, whereas Gerding (1995) estimated an increase of 2,380 to 8,680 employees (expressed in number of people involved in peat extraction) for the 1825-1900 period.

reconstruction proceeded swiftly after the Armistice, Belgian industry missed opportunities to modernise its industrial infrastructure, with the steel sector not adopting American mass production techniques and machine building factories continuing to focus on old steam technology rather than electrical engineering (Geerkens 2004). Consequently, rising protectionism hit Belgium particularly hard. The nationalisation of railway networks in many countries led to dwindling exports of locomotives and rolling stock (Maizels 1963). For Dutch industrial companies, on the contrary, the fall in international trade during the 1920's and 1930's offered an opportunity to grow, in part thanks to continuing import substitution and decreasing foreign competition (De Jong 1999).

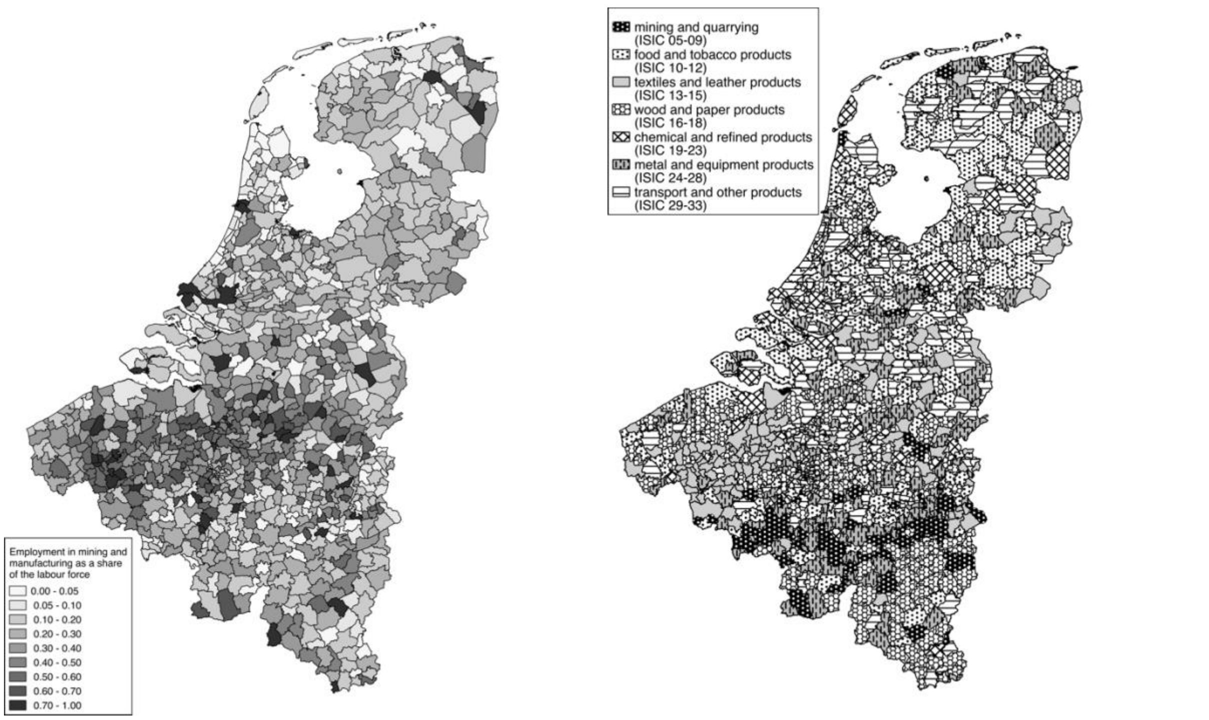
In 1930 (see figure 9), we arrive at a new economic geography of the industry sector in both countries. Over the long nineteenth century and the interwar period, regional specialisation caused regions with human capital, large consumer markets, and export facilities to become more appealing for firms (Ronsse and Rayp 2016; Philips, Foldvari and Van Leeuwen 2017). The ports of Amsterdam, Rotterdam, Antwerp, and Zeebrugge and their surroundings benefitted strongly from these changing location factors. Growth for the port of Rotterdam was most spectacular, when the construction of the *Nieuwe Waterweg* in 1872 enabled direct access from the harbour to the sea, thereby becoming an important shackle between the Ruhr area and its export regions (Loyen, Buyst and Devos 2003). Most of these gateways quickly broadened their manufacturing base beyond the traditional port-related industries, such as ship construction, to newly-emerging industries such as coke smelting, chemical products, and the production of domestic appliances such as telephone equipment, photographic paper, and cars. Most exemplary in this perspective, was the rise of a small lightning bulb company that would evolve into a key player for the domestic appliance products market: Philips. Lastly, the discovery of coal deposits in the late 1890s pulled Belgian and Dutch Limburg out of their peripheral status (Gales 1996).

2.2.3. Aggregate patterns during the post-industrial phase (1960 – 2010)

Similar to the First World War, the Second World War hit both countries in an unequal fashion. However, now the Netherlands suffered relatively more than its southern neighbour, thanks to the earlier liberation of Belgium and its swift incorporation in the allied war machine. For example: the loss in capital stock in 1945 relative to the pre-war numbers was estimated in Belgium to be 5%, whereas in the Netherlands it was 27% (Griffiths and Van Zanden 1989, 186).

Nevertheless, both countries recovered quickly: the Netherlands, for instance, by 1948 saw its capital stock already surpassing the capital stock of 1938 (De Jong 1999, 332). The coal mining sector in the Hainaut, Liège, Dutch Limburg, and Belgian Limburg provinces initially even benefitted from the aftermath of the war, as they were specialised in products that served the reconstruction of Europe, such as coal, cement and glass (Baudhuin 1958). Both countries benefitted from the Marshall plan, although its effect on economic growth has been considered fairly modest. Most aid in the Netherlands went to the restoration of financial and price stability (Clerx 1986), whereas in Belgium it was used for investments in traditional sectors such as metallurgy and mining, at the expense of higher innovating industry branches (Cassiers 1993). The early economic unification of (Western) Europe had a more beneficial effect on both countries, with the establishment of the Benelux customs union in 1944, the European Coal and Steel Community in 1951, and the European Economic Community in 1957.

Figure 10. Employment in mining and manufacturing sectors in Belgium and the Netherlands in 1970/1971, as a percentage of the labour force



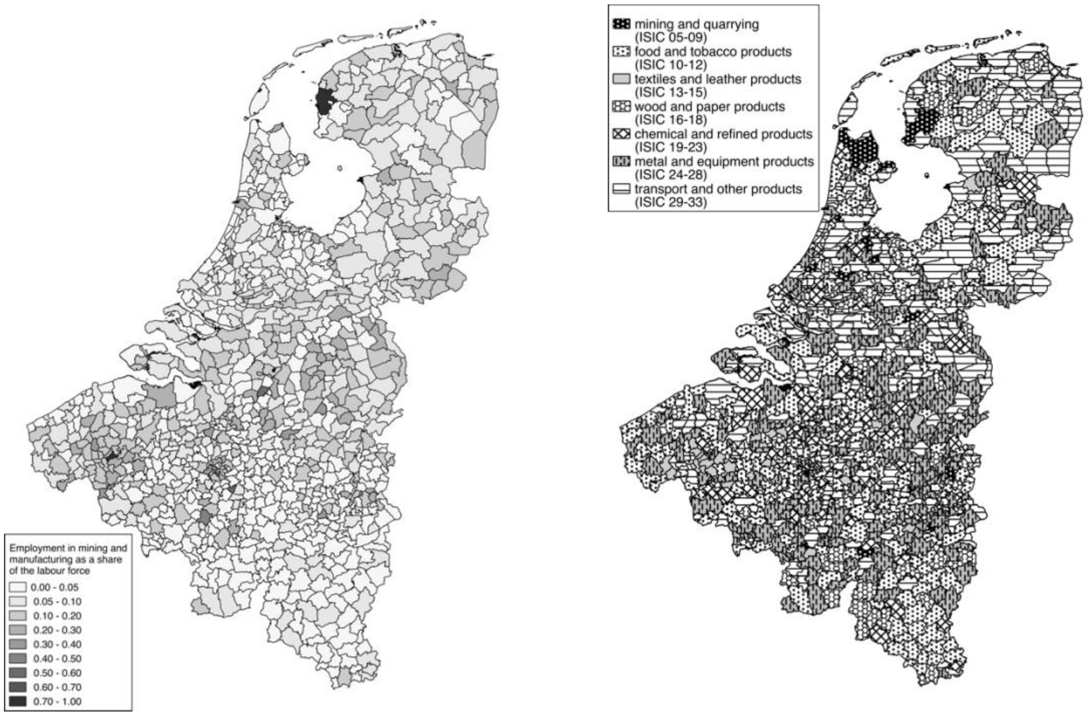
employment in industry (as a percentage of the labour force) | largest manufacturing sector within region

Turning to the results of 1970 in figure 10, we find that one major change caused an even larger shock to the industrial geography of both countries. The breakthrough of oil as the major energy source in the mid-1950's resulted in two contrasting outcomes. On the one hand, the major trade hubs and their surroundings benefitted strongly from the invasion of cheap oil, as ports became a favoured location for oil refineries and petrochemical plants. In Antwerp, the expansion in car assembly, chemicals, metal processing, ship construction, food products, and the production of consumer durables more than covered the loss of employment in more traditional activities (Van der Wee 1997). In Rotterdam, not only a significant part of the city centre took blows by the Luftwaffe in 1940, but so did the harbour infrastructure. During reconstruction, the harbour territory was significantly extended with the Europoort and Maasvlakte, thanks to which Rotterdam had become the largest harbour in the world by 1962; a position they were able to maintain until Shanghai took Rotterdam's scalp in 2005. As a result of agglomeration, the industrial heartland in Belgium had moved by 1970 to the triangle between the major cities of Ghent, Antwerp, and Brussels, with smaller clusters around the cities of Kortrijk and Liège. In the Netherlands, a similar pattern of agglomeration unfolded, with the development of an industrial heartland in the North Holland, South Holland, Utrecht and North Brabant provinces.

On the other hand, the shift to oil dealt a mortal blow to the Hainaut and Liège regions, where suddenly dozens of coal pits had to be closed down. To cope with these and other structural problems, the Belgian government launched in 1959 the so-called expansion laws, the Belgian variant of regional policy. These reforms launched various tax incentives, subsidies and the development of well-equipped industrial sites, in order to lure foreign investments to areas facing structural difficulties. But to little avail for the mining provinces: the high wages in coal mining had pushed up labour costs in other sectors too, decreasing the attractiveness of these regions for foreign investors. After the collapse of mining, it proved very difficult to reduce wages due to labour market rigidities. Competitiveness problems and adverse labour relations often deterred potential investors, which triggered a long de-industrialisation process (Brion and Moreau 1998). In Belgian and Dutch Limburg, employment in the mining sectors faced a similar but smaller shock compared to Hainaut and Liège, due to the construction of more recent infrastructure, a lower wage rate, and a broader industry mix.

By 2010 (see figure 11), we arrive at a relatively equal distribution of manufacturing activities, not in the least due to the much lower level of employment in manufacturing. The oil shocks of the 1970's, global market integration, and the continuous widening and deepening of European integration provided a strong incentive for domestic and multinational companies to move industrial activities to other countries in the European and global periphery. Additionally, technological improvements and productivity increases implicated decreasing employment numbers, especially for the sectors with high unit labour costs.

Figure 11. Employment in mining and manufacturing sectors in Belgium and the Netherlands in 2010, as a percentage of the labour force



employment in industry (as a percentage of the labour force) | largest manufacturing sector within region

This disappearance of industry jobs occurred very unequally across regions. For most regions, de-industrialisation highlighted a trajectory from a manufacturing-centred economy to a higher productive service-based economy. In this setting, the loss of industry employment was more than compensated by the creation of new service-based jobs. Such a pattern unfolded in most of the Antwerp, North Holland, South Holland, and the Flemish and Walloon Brabant provinces (after the subdivision between Flemish-Brabant and Walloon-Brabant in 1995), due to the relatively easy access to export facilities and their central location in the centre of Western Europe. For the more peripheral regions, efforts for safeguarding existing employment or attracting new (foreign) investments appeared to be a greater challenge. In figure 11, the success of the North Brabant province comes to the forefront, with the city of Eindhoven becoming a cluster for high technology, whereas the province was able to attract a lot of large multinational companies in chemicals, transport, food processing, and equipment products. A similar pattern emerged for West Flanders and Belgian Limburg.

However, the victims of de-industrialisation include the Dutch northern and eastern regions and the Belgian southern regions, where industrial activities nearly faded away. In hindsight, especially the reversal of fortune in Hainaut, Namur, Luxembourg, and Liège stand out, as they belong to the top 4 regions in Europe where relative gross domestic product per capita levels have dropped the most during the 1900 – 2010 period (Rosés and Wolf 2018). In these regions, the steel industry had to go through a painful phase of downsizing as a result of growing international competition (Buyst 1997; Nagels 2002). This process was even more hurtful due to the so-called *waffle iron politics*, according to which government funds had to be distributed equally across the Belgian northern and southern half. As a result, the political parties linked to the powerful miners' unions obtained ever more subsidies from the government to cover for the mounting losses in dwindling industries, leading to a misallocation of investments to existing activities in an attempt to safeguard employment in the Hainaut and Liège regions, instead of devising a future-oriented restructuring economic policy.

2.3. Regional specialization in the location of industry

For the evolution of regional specialization over time, two lines of theoretical contributions have been developed: one which emphasizes the role of comparative advantage and one which emphasizes the role of markets and agglomeration forces. Both theories suggest a bell-shaped, or inverted U-shaped, pattern in industrial specialization across regions, with an initial increase in specialization, followed by a decrease. On the one hand, following neoclassical growth models (see e.g. Solow 1956), it is argued that regions will specialize in certain sectors based on different costs related to labour and capital. As factor endowments converge over time by trading, industrial structures and regional incomes become increasingly similar. On the other hand, research in the line of New Economic Geography studies (see e.g. Krugman 1991; Krugman and Venables 1995) argue that increasing returns in human and physical capital lead to specialization and subsequently, divergence in regional incomes. When transport costs start to decline and costs of agglomeration increase due to scale effects, agglomeration forces are reversed into forces of dispersion, causing spatial inequalities to decline and regional specialization levels to converge.

Kim (1995; 1998) and Betran (2011) found respectively for the US (1860 – 1987) and Spain (1856 – 2002) empirical evidence for the existence of such a bell-shaped pattern of regional specialization in industry, while partial evidence for a larger number of European countries suggests similar evolutions for shorter periods of time (Crafts and Mulatu 2005; Wolf 2007; Berger, Enflo, and Henning 2012; Missiaia 2015; Nikolic 2018). In order to compare the level of regional specialization in the Netherlands and Belgium within an international setting, we calculated a Krugman specialization index (1991).[8] The index is measured as the following:

$$KSI_r = \sum_i (s_{r,i} - s_i) \quad \textbf{(1)}$$

where $s_{r,i}$ is the share of sector $_i$ of total employment in region $_r$ and s_i is the share of sector $_i$ in the overall country. The numerical value of the specialization index ranges from 0, in the case that the regions have an identical sector structure compared to the national structure, to 2, in which the sector structure is completely different across regions.

Table 3. Krugman specialization index across levels of spatial aggregation, 1820-2010

	1820	**1850**	**1890**	**1930**	**1970**	**2010**
Belgium						
NUTS1 level or regions (n=3)	0.62	0.42	0.52	0.56	0.42	0.33
NUTS2 level or provinces (n=11)	0.71	0.63	0.63	0.77	0.66	0.50
NUTS3 level or arrondissements (n=44)		0.78	0.80	1.06	0.93	0.80
LAU2 level or municipalities (n=578)		1.16	1.13	1.46	1.47	1.17
the Netherlands						
NUTS1 level or regions (n=4)	0.37	0.36	0.42	0.49	0.30	0.22
NUTS2 level or provinces (n=12)	0.48	0.51	0.57	0.61	0.43	0.34
NUTS3 level or COROP regions (n=40)		0.83	0.80	0.93	0.82	0.67
LAU2 level or municipalities (n=426)		0.82	0.87	1.06	1.12	0.97
International studies						
United States, states (Sukkoo 1998)		0,69	0.59	0.89	0.57	0.43
Spain, NUTS2 (Betran 2012)		0.53	0.60	0.91	0.69	0.62
Great Britain, NUTS1 (Crafts and Mulatu 2005)		0.66	0.64	0.72		
Italy, NUTS2 (Missiaia 2014)		0.93	0.93	0.93		
Sweden, NUTS1 (Berger, Enflo and Henning 2012)			0.15	0.20	0.23	
Sweden, NUTS3 (Berger, Enflo and Henning 2012)			0.41	0.43	0.62	
Yugoslavia, present-day countries (Nikolic 2018)				0.59	0.42	
Poland, NUTS2 (Wolf 2007)				0.33		

[8] Although recently more refined methods to measure regional specialization were developed, we decided to use the Krugman specialization index as most of the aforementioned studies used this index (or an index that closely resembled the Krugman index). So did Crafts and Mulatu (2005), Wolf (2007), Betran (2012), and Nikolic (2018) all use a Krugman index. In contrast, Kim (1998) and Berger, Enflo, and Henning (2012) calculated specialization with a highly resembling yet different index. Nonetheless, as the indices of Kim (1998) and Berger, Enflo, and Henning (2012) closely resembled the Krugman specialization index, we believe that the comparison still holds ground for this illustrative purpose.

Similar to the aforementioned studies, our results for the Netherlands and Belgium (see table 3) indicate a bell-shaped curve, with a gradual rise in regional specialization during the 1820-1930 period, after which a stabilization and continuous decline follows until 2010, where regional specialization in 2010 seems to be lower than its level in 1820. This bell-shape curve seems robust across all levels of spatial aggregation. For the NUTS1-3 levels, the highest point of the bell-shaped curve in the Netherlands and Belgium is found in 1930, in line with the studies on European countries which all placed this point during the interbellum.[9] Nonetheless, on the smaller LAU2 level, the summit of the bell-shaped curve is reached in 1970. Intuitively, we could expect a higher variation in the industry mix on lower spatial scales, a finding in line with the evidence for Sweden provided by Berger, Enflo and Henning (2012). Although national market integration and improved costs removed many obstacles across regions before 1930, it appears that on the small LAU2 scale specialization arose until 1970, with the exponential rise of car and truck transport.

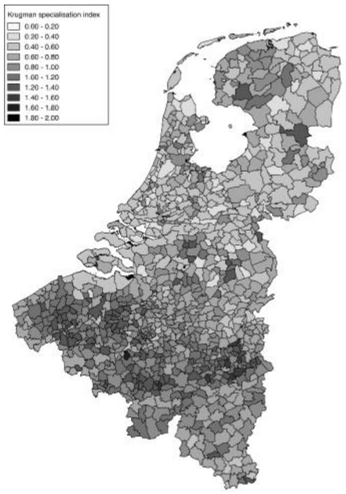
At the same time, we find evidence to nuance the existence of the bell-shape curve, thanks to the decline in regional specialization in Belgium during the 1820-1850 period, for both the NUTS1 and NUTS2 level. On second sight, a similar decline in regional specialization seems to have unfolded for the USA (Kim 1998) and Britain (Crafts and Mulatu 2005), respectively during 1860-1880 and 1870-1900, although these findings went unnoticed by the aforementioned authors.[10] When turning to the decomposed values of regional specialization on the NUTS1 and NUTS2 level (available upon request), we find two evolutions responsible for this decline in regional specialization in Belgium during 1820-1850. First, the decline of the widespread domestic linen industry in the East and West Flanders provinces during the first half of the nineteenth century caused a convergence in the industry mix across regions. Second, the market integration of the smaller Limburg, Namur, and Luxembourg provinces in the larger

[9] The highest point was found for the United States in 1914-1927 (0.89), Britain in 1921 (0.79), Spain in 1929 (0.91), Poland in 1937 (0.39), Yugoslavia in 1939-1953 (0.62), and Sweden in 1940 (0.44), in respectively the studies of Kim (1995), Crafts and Mulatu (2005), Betran (2011), Wolf (2007), Nikolic (2018) and Berger, Enflo, and Henning (2012). The findings of Missiaia (2014) for Italy indicate a relatively stable pattern for the 1871–1911 period, but as they do not provide any estimations for later or earlier benchmark years, we disregarded this evidence.

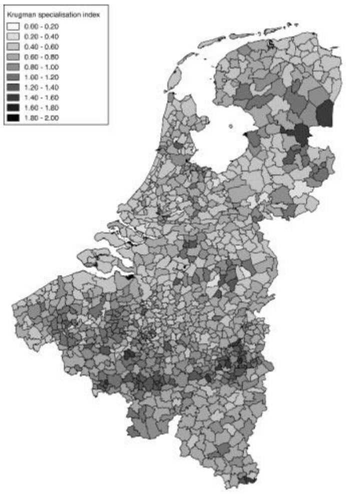
[10] Kim (1995: 887) only mentioned that "the degree of regional specialization rose between 1860 and World War I after a slight decline between 1860 and 1890.". Neither did Betran (2012) devoted much attention to the finding of Kim (1995), as he noted that "in the case of the USA, regional specialization increases from 1860 to 1910" (Betran 2012: 265).

national economy were responsible for significant drops in their respective regional specialization levels.

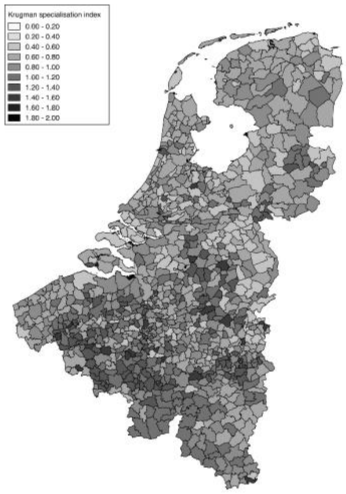
Figure 12. Krugman specialization index on LAU2 level, 1850-2010



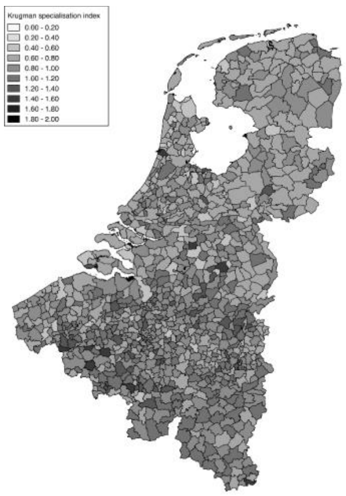
1850



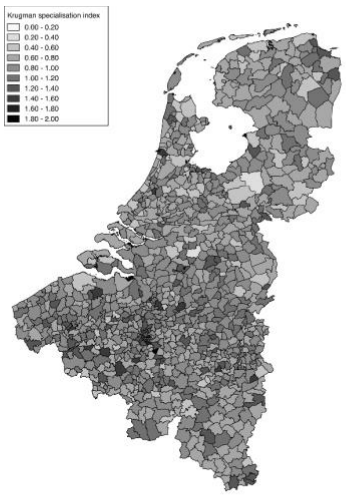
1890



1930



1970



2010

Compared to the evidence on other countries, we find relative high regional specialization in Belgium and relative low specialization in the Netherlands, which seems robust over all levels of spatial aggregation. The higher starting point of Belgium in 1820 seems to play a pivotal role for this difference, as the gap between both countries remains more or less constant during the 1820-2010 period. Here, both comparative advantage and agglomeration forces can explain this difference in 1820. As for comparative advantage, Dutch industry in 1820 was highly specialized in foodstuffs and tobacco industries, both sectors with a relative low level of localization. In contrast, Belgium's industry leaned more to sectors with high inputs of domestic factor endowments, with the linen industry and metallurgy sectors depending respectively on local flax production as well as domestic coal and wood inputs. As for agglomeration forces, both countries faced a very different transport network. Here, the Netherlands benefitted from its well-connected network of harbours and canals in the western part of the country, the multitude of rivers connecting the southern and eastern region to this western heartland, combined with low elevation extremes throughout the country. Belgium on the other hand lacked substantial transport infrastructure investment before the 1830s, supplemented with higher transport costs in its elevated southern region. Similar evidence was found by Dejongh, Van Campenhout, and Ceusters (2000), who studied market integration in Belgian urban grain markets during 1700-1850. In their study, the highest increases in market integration were found for the last decades under study, when the peripheral eastern and southern parts of the country became integrated after the construction of paved roads.

More variation lights up when turning to the specialization index on the LAU2 level (see figure 2). By the second half of the nineteenth century, three regions appear to be the forerunners of regional specialization. First, the Dutch northern regions, where a lack of major waterways caused high transport costs, preventing market integration with the rest of the country. Second, the Belgian southern region, where a specific industry mix was developed, dominated by coal and metals. Third, in Flanders or the Belgian northwest, the industry mix was dominated by the low-waged widespread domestic linen industry. These high specialization levels seem to persist throughout the rest of the nineteenth century in the Dutch northern region and the Belgian southern region, thanks to increasing activities in respectively peat bogs extraction and coal mining, two sectors with notable high localization values. In 1930, on the top of the inverted bell-shaped curve, we find that regional specialization had declined in most of these regions, especially in the Dutch north due to the decline of peat extraction and in Flanders due to the decline of the domestic linen production. In the Belgian south, although the introduction of railroads had improved access to the northern domestic market and international markets, the high localization in coal and metallurgy prevented convergence for this region. During the rest of the twentieth century, we find an overall convergence, thanks to which most of these regional differences in specialization flat out.

2.4. Path dependence in the location of industry

Although path dependence was originally developed as a theory of technological diffusion by David (1985; 2007) and Arthur (1989; 1994), both authors highlighted examples of industrial location patterns in their studies,[11] which in turn attracted attention in economic geography studies in recent decades (e.g. Martin and Sunley 2006; Boschma and Frenken 2007; Martin 2010; Henning, Stam and Wenting 2012). Although definitions vary widely over these studies, most of these studies argued that specialization or a lack of diversification increases the likeliness for a region to become path dependent, to the point that a region could become 'locked in', lacking the capabilities to attract new economic activities (Hobor 2016; Martin et al. 2016; Brown and Greenbaum 2017). In addition, we find two economic history studies which have explored this topic so far: Crafts and Wolf (2014), who found that the location of textiles factories in 1838 in the UK largely followed the spatial distribution of the then-redundant cotton mills, and Nikolic (2018), who similarly tested for the effect of path dependency in the location of industry in Yugoslavia during 1932-1939.

Nonetheless, the economic geography and the economic history studies alike expressed the need for further empirical research, as Martin and Sunley (2006: 42) argued that 'we need to historicise the prevalence and strength of path dependence itself' and Nikolic (2018: 120) that 'an interesting avenue for future research could be to establish just how far-reaching are the effects of Path Dependence on the present day location of industrial activity'. Therefore, to roughly measure the strength of path dependence across regions and time, we developed a path dependence index (PDI), for which we have built upon the 'inherited industry ratio' of Nikolic (2018).[12] We defined this index as:

$$PDI_{i,t} = 2 - \sum_r (s_{r,i,t-1} - s_{r,i,t}) \quad \textbf{(2)}$$

[11] Arthur (1994: 49) devoted his fourth chapter to 'industry location patterns and the importance of history', while David (2007: 92) argued that 'one would expect it to figure especially prominently in the analytical consciousness of economic historians, and to be equally familiar to all who are concerned to study the evolution of technologies, institutions, firms' strategies and industry structures'.

[12] Nikolic (2018) defined the inherited industry ratio as the total number of factories established pre-1918 in region $_i$ divided by the total number of factories established during interwar in region $_r$ by year $_t$. We deviated in three respects from Nikolic's index. First, we took the share of employment in the total employment, instead of the number of factories. Second, we added the sectoral component, by including the share in sector $_i$. Third, we took the inverse of the index.

where we take the difference between the share of employment in sector $_i$, region $_r$ and year $_{t-1}$ and the share of employment in sector $_i$, region $_r$ and year $_t$, after which we sum all regional shares for each industry $_i$ in each year $_t$. The numerical value of the path dependence index ranges from 0 to 2, where a low numerical value indicates relative change in the industry base and a high numerical value indicates high continuity in the location of industry. Similarly, we can measure path dependence index across regions by adapting equation (2) to:

$$PDI_{r,t} = 2 - \sum_i (s_{r,i,t-1} - s_{r,i,t}) \quad \textbf{(3)}$$

where we take the difference between the share of employment in sector $_i$, region $_r$ and year $_{t-1}$ and the share of employment in sector $_i$, region $_r$ and year $_t$, after which we take the sum of all sectoral shares for each region $_r$ in each year $_t$. In tables 4 and 5, we reported for Belgium and the Netherlands the path dependence index across industry branches, taking the ISIC division level 2 as industry $_i$. Additionally, in figure 13, we reported the index on the LAU2 level, where we took the municipalities in Belgium and the Netherlands as region $_r$.

Table 4. Path dependence index in Belgium, 1850-2010

ISIC Division		**1850-1890**	**1890-1930**	**1930-1970**	**1970-2010**	**1850-2010**
5	Mining of coal and lignite	1,994	1,473	1,413	0,565	0,612
6	Extraction of crude petroleum and natural gas	-	-	-	-	-
7	Mining of metal ores	1,769	0,264	1,404	-	-
8	Other mining and quarrying	1,928	1,436	1,346	0,743	0,563
9	Mining support service activities	-	-	-	-	-
10	Food products	1,875	1,190	1,417	1,120	0,926
11	Beverages	1,795	1,378	1,480	0,432	0,291
12	Tobacco products	1,491	1,082	1,317	0,104	0,064
13	Textiles	1,534	1,313	1,489	0,943	0,626
14	Wearing apparel	1,966	1,126	1,371	0,764	0,783
15	Leather and related products	1,905	0,882	1,224	0,399	0,425
16	Wood and of products of wood and cork	1,114	1,383	0,920	0,644	0,808
17	Paper and paper products	1,280	1,185	1,626	0,556	0,462
18	Printing and reproduction of recorded media	1,423	1,573	1,589	0,867	0,724
19	Coke and refined petroleum products	-	0,539	1,548	0,073	-
20	Chemicals and chemical products	1,387	0,924	1,497	0,878	0,629
21	Pharmaceutical, medicinal, botanical products	1,456	0,876	1,601	0,191	0,227
22	Rubber and plastics products	1,666	0,549	1,305	0,302	0,036
23	Other non-metallic mineral products	1,747	1,135	1,196	0,782	0,381
24	Basic metals	1,889	1,397	1,505	0,489	0,417
25	Fabricated metal products	1,821	1,234	1,354	0,853	0,792
26	Computer, electronic and optical products	1,787	0,896	1,555	0,396	0,253
27	Electrical equipment	1,732	0,412	1,438	0,237	0,207
28	Machinery and equipment	1,838	1,044	1,428	0,838	0,475
29	Motor vehicles, trailers and semi-trailers	1,762	0,960	1,518	0,350	0,367
30	Other transport equipment	1,886	0,991	1,466	0,251	0,376
31	Furniture	-	1,242	1,499	0,670	-
32	Other manufacturing	1,568	1,224	1,471	0,638	0,630
33	Repair and installation of equipment	-	0,120	1,803	0,124	-
Weighted average		**1,685**	**1,194**	**1,364**	**0,694**	**0,529**

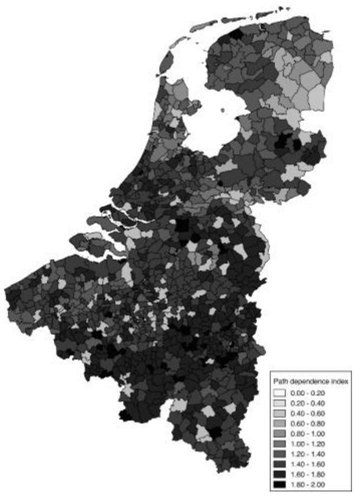
Table 5. Path dependence index in the Netherlands, 1850-2010

ISIC Division		**1850-1890**	**1890-1930**	**1930-1970**	**1970-2010**	**1850-2010**
5	Mining of coal and lignite	-	-	-	-	-
6	Extraction of crude petroleum and natural gas	-	-	-	-	-
7	Mining of metal ores	-	-	-	-	-
8	Other mining and quarrying	0,954	0,560	0,263	0,289	0,220
9	Mining support service activities	-	-	-	-	-
10	Food products	1,887	1,202	1,105	1,433	1,130
11	Beverages	1,091	0,981	0,612	1,034	0,438
12	Tobacco products	1,512	0,899	0,686	0,646	0,112
13	Textiles	1,452	0,893	0,704	1,018	0,765
14	Wearing apparel	1,853	0,797	0,709	1,144	0,953
15	Leather and related products	1,683	1,080	0,794	1,104	0,711
16	Wood and of products of wood and cork	1,561	0,918	0,852	1,230	0,876
17	Paper and paper products	1,216	0,496	0,644	1,157	0,440
18	Printing and reproduction of recorded media	1,655	1,058	1,084	1,105	0,789
19	Coke and refined petroleum products	-	0,244	0,117	1,179	-
20	Chemicals and chemical products	1,635	0,536	0,713	1,242	0,283
21	Pharmaceutical, medicinal, botanical products	-	0,149	0,094	0,997	-
22	Rubber and plastics products	-	-	0,291	1,227	-
23	Other non-metallic mineral products	1,194	1,083	0,845	1,295	0,536
24	Basic metals	-	1,001	0,352	1,507	-
25	Fabricated metal products	1,764	0,959	0,701	1,097	1,032
26	Computer, electronic and optical products	0,961	0,593	0,386	0,741	0,403
27	Electrical equipment	-	0,528	0,599	1,021	-
28	Machinery and equipment	1,403	0,572	0,502	1,214	0,383
29	Motor vehicles, trailers and semi-trailers	1,842	0,917	0,416	1,195	0,371
30	Other transport equipment	1,564	0,726	0,871	0,785	0,626
31	Furniture	-	0,976	0,812	1,242	-
32	Other manufacturing	1,085	1,199	0,627	1,001	0,710
33	Repair and installation of equipment	-	-	0,489	0,541	-
Weighted average		**1,560**	**0,948**	**0,706**	**1,141**	**0,586**

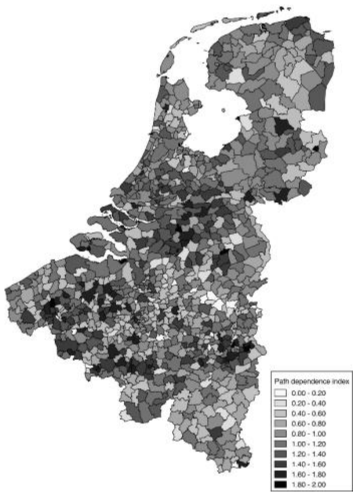
Overall, we find a declining path dependence index over the 1850-2010 period for both countries. Sectors related to the production of mining, food, and metal products are the sectors most inclined to become path dependent, because of their reliance upon place-dependent inputs such as agricultural products and natural resources (see tables 4 and 5). In contrast, the production of pharmaceutical, electrical, and rubber products are found to be least bound by path dependence (see tables 4 and 5), most likely due to the relative high occurrence of technological breakthroughs in these sectors and its higher reliance on diversified and imported inputs.

Additionally, we find a higher path dependence index for Belgium as compared to the Netherlands for the 1850-1970 period. Here, we can hypothesize that the lower share of capital-intensive sectors in the Netherlands played a large role in the lower path dependence index, given the higher relocation costs for such sectors (see e.g. Crafts and Mulatu 2014; Nikolic 2018). Two smaller periods in both countries seem to break with this trend of a declining path dependence index: 1930-1970 for Belgium and 1970-2010 for the Netherlands. The first could be credited to the continuity in the location of metallurgy and other capital-intensive sectors in Belgium, most notably alongside the industrial axis of the Meuse-Sambre valley where these industries clustered (see figure 13). The latter increase could be credited to the spike in path dependence in the food producing sector (see table 5), a sector that dominated the Dutch industry mix in 1970, most notably in the peripheral Dutch northern and eastern regions (see figure 13).

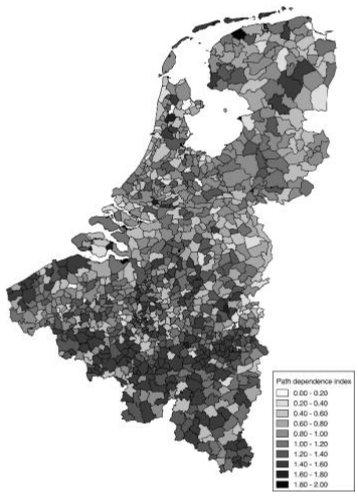
Figure 13. Path dependence index on LAU2 level, 1850-2010



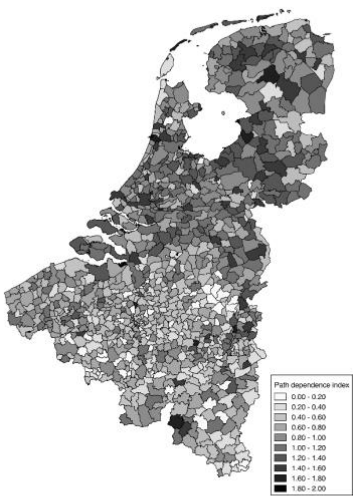
1850-1890



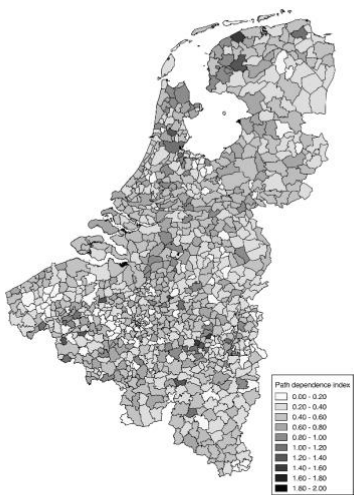
1890-1930



1930-1970



1970-2010



1850-2010

In Belgium, the highest values are found in the north of Wallonia, where metal production dependable upon non-moveable coal mines resulted in a strong continuation in the industry base. Additionally, small clusters light up, such as the small area in the south of West Flanders clustering around the city of Kortrijk. Here, a fraction of the once-flourishing linen producing heartland of Flanders was able to make the jump to mechanization in the late nineteenth century. In the Netherlands, we find for the 1850-1930 period a strong continuation in the location of industry for the western Holland and southern North Brabant regions. For these regions, the rapid expansion of the industry sector during the 1950s – 1960s implied the introduction of pharmaceuticals, rubber and plastics, and refined petroleum production, inducting a break with the existent industry base in these regions (Atzema and Wever 1994). In contrast, the Dutch eastern and northern regions experienced rapid changes in their industry bases throughout the entire period of study. First, throughout the nineteenth century, during which in the Dutch north many handicraft businesses disappeared (De Jonge 1968) and in the Dutch east textiles production rapidly mechanized (Jansen 1999). Second, throughout the twentieth century, when many industries relocated out of the peripheral regions, as the rapid Dutch expansion of its industry sector disproportionally benefitted the higher populated western and southern regions (Atzema and Wever 1994).

2.4. Determinants of path dependence in the location of industry

With these varying degrees of path dependence across countries, regions, and industries, we have an ideal case study to test for the determinants of path dependence. Not surprisingly, theories about the causes of path dependence have been developed since the formulation of the concept, causing debates in which even David (1985; 2007) and Arthur (1989; 1994) took a stand.[13] As regards to path dependency in the location of industry specifically, both Crafts and Wolf (2014) and Nikolic (2018) have hypothesized about its determinants. Crafts and Wolf (2014) argued that '[f]irst, there can be positive feedback effects due to market access as highlighted in New Economic Geography models in the wake of Krugman (1991). Second, sunk costs can introduce another form of hysteresis in location choice that can delay relocation'

[13] David (1985; 2007) attributes path dependence to three different sets of mechanisms: 'system scale economies' (in which a self-reinforcing application of a given, less inefficient technology is chosen over the most efficient technology), 'technical interrelatedness' (as an interaction effect that complements path-dependent development), and 'quasi-irreversibility of investment' (the adaption costs of developing an alternative from the path-dependent development). In contrast, Arthur (1989; 1994) argued that path dependence exclusively occurs in case of 'increasing returns', which roughly comes down to the same as 'increasing returns' to the first mechanism of David (1985; 2007).

(Crafts and Wolf 2014: 1110), of which both effects relate to mechanisms identified by David (1985; 2007) and Arthur (1989; 1994).[14] Here, Crafts and Wolf (2014) found significant effects through both channels, whereas Nikolic (2018) tested exclusively for path dependence through the channel of sunk costs.

Although both the studies of Crafts and Wolf (2014) as Nikolic (2018) have empirically proven a significant effect of path dependency on the location of industry, the strength of both determinants remains untested, leading Martin and Sunley (2006: 41) to argue that 'we need to know more about what determines the strength of the processes in different locations'. To forward this debate, here we test the relative importance of the two main determinants of path dependence as identified by Crafts and Wolf (2014): both through the positive feedback effect and the sunk cost effect. For this, average plant size per sector is used as a measure of path dependence through the positive feedback effect, whereas capital intensity per sector is used as a measure of path dependence through the sunk cost effect. To estimate the average plant size, we divided the total number of establishments by the total number of employees, for which both numbers were derived from the industry censuses. To estimate the capital intensity per industry branch, we divided the total value of fixed-asset capital by the number of employees for each industry sector, which we transformed as a relative sectoral share of the total capital intensity in all industry sectors.[15] We can write this as:

$$PDI_{i,c,t} = \beta_0 + \beta_1 \text{ Average plant size}_{i,c,t-1} + \beta_2 \text{ Capital intensity}_{i,c,t-1} + \varepsilon_{i,c,t} \qquad \textbf{(4)}$$

in which the path dependence index in sector $_i$, country $_c$, and year $_t$ (as the difference between the share of employment in sector $_i$, country $_c$, and year $_{t-1}$ and the share of employment in sector $_i$, region $_r$ and year $_t$) is explained by the average plant size sector $_i$, country $_c$, and in year $_{t-1}$ and capital intensity in sector $_i$, country $_c$, and year $_{t-1}$. We use a fixed-effects model, using least squares dummy variables to account for effects related to individual industry sectors

[14] Crafts and Wolf (2014) roughly interpreted the first mechanism as the main definition of path dependency by Arthur (1989, 1994) or the first definition by David (1985, 2007), while the second mechanism roughly comes down to the third definition of David (1985, 2007).

[15] For 1850-1890, we used the total number of steam engines which were reported in the aforementioned industry censuses (see section 2). For the 1930 period, we used the total amount of omitted horse power of all steam engines and all electrical motors, as reported in the Dutch and Belgian industry censuses of 1930 (see section 2). We multiplied these numbers with the installation and maintenance costs per machine, which was reported for the 1820-1890 period by Lintsen (1993) and for 1930 by De La Bruhèze et al. (2000). For the benchmark years 1970 and 2010, we used an indirect approach of estimating the value of fixed- asset capital, by taking the total capital stock across sectors, drawn from Statistics Belgium and the CBS in the Netherlands.

and individual time periods. To differentiate across countries and time periods, we differentiated in our results in table 6 between Belgium and the Netherlands, and in table 7 between time periods, subdivided in the 1850-1930 period and the 1930-2010 period. For each group of results, we reported respectively in the first column the Ordinary Least Square (OLS) estimates, after which we controlled for year-fixed effects and sector-fixed effects in respectively the second and third column, and for both fixed effects in the fourth column.

Table 6. Estimation of the determinants of path dependence, differentiated across countries

	dependent variable: path dependence index							
	Belgium				the Netherlands			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Average plant size	0.170***	0.176***	0.147***	0.148***	0.152***	0.190***	0.141***	0.145***
	(0.0309)	(0.0215)	(0.0340)	(0.0342)	(0.0188)	(0.0153)	(0.0274)	(0.0277)
Capital intensity	1.438***	1.434***	1.297**	1.299**	1.564***	1.490***	1.222**	1.238**
	(0.513)	(0.357)	(0.686)	(0.691)	(0.414)	(0.318)	(0.657)	(0.659)
Constant	0.353***	0.698***	0.820**	1.183***	0.159**	0.394***	0.518***	0.311**
	(0.119)	(0.101)	(0.346)	(0.219)	(0.0699)	(0.0659)	(0.207)	(0.158)
Year fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
Sector fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	116	116	116	116	116	116	116	116
R-squared	0.2732	0.6560	0.4035	0.7840	0.4715	0.6988	0.5915	0.7824

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 7. Estimation of the determinants of path dependence, differentiated across time

	dependent variable: path dependence index							
	1850-1930				1930-2010			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Average plant size	0.163***	0.200***	0.0601*	0.140***	0.161***	0.166***	0.156**	0.177***
	(0.0236)	(0.0205)	(0.0352)	(0.0315)	(0.0265)	(0.0253)	(0.0620)	(0.0594)
Capital intensity	1.505***	1.458***	3.169***	3.361***	1.638***	1.637***	1.457	1.730
	(0.460)	(0.386)	(1.218)	(1.002)	(0.514)	(0.491)	(2.144)	(2.043)
Constant	0.326***	0.495***	0.489*	0.690***	0.169*	0.0257	0.153	0.164
	(0.0930)	(0.0816)	(0.279)	(0.232)	(0.0968)	(0.101)	(0.269)	(0.0580)
Year fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
Sector fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Observations	116	116	116	116	116	116	116	116
R-squared	0.3826	0.5702	0.5753	0.7160	0.3313	0.3961	0.3778	0.4429

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

The results in Tables 6 and 7 provide empirical support for both a positive feedback effect and a sunk cost effect on path dependence in the location of industry in the Netherlands and Belgium. The coefficients of both effects are significant and positive. The R2 is robust and increases when controlled for year-specific and industry-specific dummy variables, with the exception of the sunk cost effect during the 1930-2010 period. This indicates that path dependence in the location of industry in the Netherlands and Belgium can jointly be explained by both sunk cost effect and positive feedback effects. Yet, we find notable differences in both effects over time: while in 1850-1930 path dependence through the sunk cost effect dominated the positive feedback effect, in 1930-2010 the coefficient of the sunk cost effect decreases and becomes insignificant when controlled for sector-specific fixed effects. Given the declining R-squared over time, we are hinted that not only the scale of path dependency but also the explanatory power of path dependence has declined over the 1850-2010 period. Explanations for this pattern concern the increase in creative destruction and the fall of transport costs, which spurred the mobility of capital and labour throughout the nineteenth and twentieth century (e.g. Betran 2011; Crafts and Mulatu 2014). In turn, this empirically affirms the views of Martin and Sunley (2006: 42), who argued that 'the strength of path dependence has been reduced by the new technological-institutional regimes evident in leading and emerging economies'.

Most notably, the explanatory power of the sunk cost effect declined over time, as capital-intensive firms acquired more agency for to relocate due to falling transport costs. As such, we can interpret the increase in path dependence in the Belgian south during the 1930s- 1970s and subsequent decrease during the 1970s-2010s. Over the nineteenth century, this region heavily specialized in capital-intensive industries, such as coal mining, heavy metallurgy, and chemical industries. After the Second World War, when these sectors faced the breakthrough of oil, increasing automation and international competition, the Belgian government devised the so-called waffle iron politics, an industrial policy according to which government funds had to be distributed equally across the Belgian northern and southern half during the 1950s – 1980s. As a consequence, the southern political parties linked to the powerful miners' unions obtained ever more subsidies from the government to cover for the mounting losses in these dwindling industries, leading to a misallocation of investments to existing activities in an attempt of safeguarding employment rather than devising a future- oriented restructuring economic policy (Buyst 1997; Nagels 2002). Yet, with declining sunk cost effects, these attempts still did not prevent the inevitable relocation of these industries during the last decades.

Conversely, we find that increasing returns continue to play a role in path dependency in the location of industry, empirical affirming that Marshallian forces continue to keep large firms within a particular region. One illustrative example concerns the food producing sector in the Netherlands, for which the highest path dependence index was found for the 1850-2010 period, even increasing the overall path dependence index in the Netherlands during the 1970s-2010s (see table 5). Lintsen and Steenaard (1991) argued that the lack of coal and abundant use of wind and water mills in the Netherlands forced Dutch entrepreneurs to focus on sectors which benefitted less from mechanization, most notably the foodstuffs sector. With increasing expansion of scale, many of these smaller companies successfully made the transition to large multinationals. Thanks to Marshallian externalities – benefitted by the strong Dutch commercial tradition, easy access to international markets, and ties to local agricultural inputs – the Netherlands often succeeded in retaining these companies within their region of origin. One notable example concerns two local merchants - Van der Bergh and Jurgens - who became in Oss the largest traders in butter in the world by the end of the nineteenth century, by developing artificial butter which circumvented costly and hard-to-get diary inputs (Atzema and Wever 1994). Both joint forces and later set up business together in Rotterdam, establishing the Unilever company in 1929, of which Rotterdam has retained its headquarters until present.

2.5. Conclusion: continuity and discontinuity in the location of industry

Like most parts of Europe, the regions in Belgium and the Netherlands experienced a process of industrialisation and rapid economic growth during the nineteenth and twentieth century. We reviewed the trends in the location of industry in these two small Western European countries, in order to shed a new light on the literature of the Industrial Revolution and subsequent periods of industrialisation in both countries. For this, we have drawn upon a new dataset on employment numbers, derived from the 1820-2010 Belgian and Dutch population and industry censuses. During this period, both countries revealed very divergent spatial patterns of industrialisation, depending on the regional-varying capacity to maintain old industrial activities while attracting newly emerging industries during the different phases of (de-)industrialisation and technological advancements.

On the eve of the Industrial Revolution and when both countries were united in the United Kingdom of the Netherlands (1815 - 1830), we find an unequal regional distribution of industrial activities in both countries in 1820. Whereas many historical studies have used the example of Belgium as an early industrialiser and the Netherlands as suffering from ‘industrial retardation’ (Griffiths 1979) based on both larger labour and capital numbers in the former country (e.g. Griffiths 1979; Mokyr 1974; Mokyr 1976; Lintsen and Steenaard 1991; Mokyr 2000), the higher employment in industry in Belgium could mostly be attributed to the widespread textiles activities in East and West Flanders, and the steam engines to the coal mining sector in the Hainaut and Liège regions. During the 1820-1850 period, we find that the industry sector in the Dutch southern and eastern provinces benefitted the most from the Belgian and Dutch break-up, at the expense of the mechanising textiles sector in the Belgian northwest.

Looking at lower geographical levels and sectoral evolutions, we find that in most regions textiles manufacturing composed by far the largest industry sector in both countries in 1850, although soon a pattern of diffusion started, with regional specialisation and cluster formation as a consequence. Most notably, we find new factories in metals and machinery in the Belgian south next to the Sambre-Meuse coal belt arising in 1850-1890. During the breakthrough of the second phase of industrialisation and the mechanisation of retail-oriented and capital-intensive sectors, industry started concentrating near centres of consumer markets and export facilities, benefitting disproportionally the Brabant and Antwerp regions in Belgium and the Holland and Utrecht region in the Netherlands. In contrast, the Belgian deep south and Dutch north pauperised. During the post-industrial phase, a process of relative decline emerged in the Dutch north-eastern and Belgian southern provinces, shaping to a large extent the current economic geography of industry in both countries.

As the nineteenth century progressed, domestic and international market integration as well as rapid technological innovation implicated a dynamic process in which old industries left the scene and new industries emerged, a process with an unequal outcome across regions. So, the tables in Belgium turned from the northern Flemish side to the southern Walloon side during the 1820-1930 period, thanks to the rapid expansion of coal mining and metal production activities in the latter region. Tables turned again during the twentieth century, when “the Brussels-Antwerp axial belt has replaced the Haine-Sambre-Meuse coalfield as the economic core of the country” (Riley 1976: 178). In contrast, in the Netherlands, the western regions compromised the industrial core of the country throughout the entire nineteenth and twentieth centuries, although the eastern regions during the second half of the nineteenth century and the southern regions from the twentieth century onwards resulted in significant competition.

In addition, our findings for the Netherlands and Belgium support the existence of a so-called bell-shaped curve in regional specialization, in line with the findings of Kim (1995; 1998) for the USA and Betran (2011) for Spain. Compared to these international studies, we find a relative high level of specialization in Belgium and a relative low level of specialization in the

Netherlands. The higher regional specialization for Belgium compared to the Netherlands in 1820 can be attributed to both differences in factor endowment structures, with the Belgian industry relying more on domestically-produced resources and Dutch industry focussing more on foreign inputs, and market integration, with Belgium having a relatively lesser developed transport network to its disposal. In the 1850-1930 period, specialization spurred in the Dutch northern, Belgian south, and north-western regions. Yet, with the decline of transport costs and international market integration after the Second World War, many of these regional differences disappeared during the 1930-2010 period.

With the increasing attention for path dependence as an explanatory factor for the location of industry (e.g. Martin and Sunley 2006; Crafts and Wolf 2014; Nikolic 2018), we measured both the strength as the explanatory factors of path dependence over time in both countries. Our findings provide empirical evidence for the decline in path dependence in the location of industry over the 1850-2010 period (Martin and Sunley 2006). Here, the sectors with high inputs of agricultural products and natural resources are found to have a higher likelihood for becoming path-dependent, in particular the industries related to mining, food and metal products. Additionally, we find a higher path dependence in Belgium during the 1850-1970s, affirming the view that regional specialization or lock-ins increase the likeness of path dependence (e.g. Grabher 2007; Hassink 2005). Although further empirical research is necessary to unravel more about the effect of path dependency on the location of industry, our evidence on the long-run trends in the location of industry of Belgium and the Netherlands provides a preliminary, though necessary, step to empirically measure the effect of path dependence. As such, the found high path dependence in the location of industry in the Dutch northern regions during the late nineteenth century and the Belgian southern regions during the late twentieth century - which both preluded the relocation of industries in subsequent periods - illustrates the relevance of historical investigations to study the role of path dependence on spatial economic patterns.

Chapter 3. The transition from proto-industrialization towards modern industrialization

(together with Wouter Ronsijn)[16]

3.1. Introduction: the relevance of proto-industrialization?

The Industrial Revolution has attracted notable attention from historians and economists alike. Yet, this transition has been interpreted in two conflicting ways. First, as a radical change of the then-existing economic structures, described with superlatives such as the "key break in world history" (Clark 2012: 85) or "one of the most celebrated watersheds in human history" (Allen 2011: 357). Second, as an acceleration of long-run evolutions already set in motion during the pre-industrial age, among which the increase in demand for manufactured products (De Vries 2008), human capital accumulation (Van Zanden 2009), urbanization (De Vries 1984), and changes in female labor force participation (De Moor and Van Zanden 2010). Part of the debate on the continuity or discontinuity between pre-industrial and modern industrial development revolves around location, an issue which became an important topic of discussion in light of the so-called proto-industrialization debate.

The theory on proto-industrialization was first developed by Franklin Mendels in his 1969 PhD thesis on the linen industry in Flanders (published in 1981), after which it was picked up by Peter Kriedte, Hans Medick and Jürgen Schlumbohm (1977; English translation in 1981). Mendels (1972: 241) argued how proto-industrialization – understood as the rise in rural, domestic, artisanal production for distant markets taking place within households partly involved in subsistence agriculture – was the "first phase of the industrialization process […] which preceded and prepared modern industrialization proper". Although Mendels (1972: 243-245, 1982: 80) and Kriedte, Medick and Schlumbohm (1981: 135-160) argued that not all

[16] This chapter is largely based upon the following working paper: Philips, R. and Ronsijn, W. "A tale of two transitions: the effect of proto-industrialization on modern industrialization in 19th-century Flanders and Eastern Netherlands". Furthermore, we would like to thank the Historical Database of Local and Cadastral Statistics LOKSTAT-POPPKAD (Quetelet Center, Ghent University), specifically Sven Vrielinck, and the Historical Sample of the Netherlands (HSN), specifically Kees Mandemakers, for providing data. Additionally, we want to thank Erik Buyst, Thijs Lambrecht, Sheilagh Ogilvie, Leigh Shaw-Taylor, Bas van Leeuwen, and Jan Luiten van Zanden for comments, as well as the participants of the 2018 workshop 'An Economic Geography of Long-Run Industrialization', the 2019 economic history seminar at Ghent University, the 2019 European Historical Economics Society Conference, and the 2019 Rural History Society Conference.

regions with prior proto-industrialization were able to experience an Industrial Revolution, Mendels (1982: 80) argued that proto-industrialization "tended to propel regions in which it was found toward an industrial revolution, or at least it facilitated their adoption of mechanization". Multiple mechanisms were hypothesized through which an initial phase of proto-industrialization could have facilitated modern industrialization: generating rapid demographic growth, training a skilled labor force, forming entrepreneurs with capital and entrepreneurial skills, generating technical knowledge for machine builders, developing commercial infrastructure with linked markets, and improving agricultural productivity to supply laborers in the industry sector.

During the 1980s and 1990s, the theory of proto-industrialization became one of the most widely discussed topics in economic history,[17] attracting both praise and criticism in the process (e.g. Jeannin 1980; Coleman 1983; Houston and Snell 1984; Clarkson 1985; Hudson 1990; Leboutte 1996; Ogilvie and Cerman 1996). Most criticism questioned to which degree proto-industrialization was a sufficient, let alone a necessary, factor in the development of modern industry. Firstly, and of most importance, it was argued that there were many proto-industrial regions that de-industrialized, while many other regions industrialized without experiencing a prior phase of proto-industrialization (e.g. Houston and Snell 1984: 488-490). For instance, Coleman (1983: 442-443) showed that, out of ten English proto-industrial regions, only four successfully developed modern industry, i.e. the majority of proto-industrial regions were unsuccessful. Secondly, the mechanisms through which proto-industrialization would have led to modern industrialization were questioned (e.g. Ogilvie and Cerman 1996: 10). For example, Clarkson (1985: 28-38) questioned the extent to which capital required to set up factories had indeed been accumulated in proto-industries.

Despite this stream of literature, consensus was not reached about the explanatory power of proto-industrialization, after which popularity for the theory seemingly faded away. For instance, in explaining the location of industry at the time of the Industrial Revolution, the historiographical focus shifted to explanations based on factor prices (e.g. Wrigley 2010; Allen 2011), access to domestic and foreign markets (e.g. Clark 2007; De Vries 2008), or human

[17] For instance, proto-industrialization was one of the main topics of the Eight International Economic History Congress in Budapest 1982. In its wake, several journals devoted special issues to proto-industries, including *Revue du Nord* (1979, 61: 240; 1981, 63: 248; 1985, 67: 265), *Scandinavian Economic History Review* (1982, 30: 1), *Annales* (1984, 39: 5), *Continuity & Change* (1993, 8: 2), and *Tijdschrift voor Sociale Geschiedenis* (1994, 20: 4).

capital (e.g. Mokyr 2009; Squicciarini and Voigtländer 2015). Nevertheless, taking the citation count of Mendels (1972) as an indicator, it appears that these studies did not halt the popularity of the theory on proto-industrialization during the 2000s and 2010s.[18] Indeed, proto-industrialization continues to weigh upon many of the debates in economic and social history, though in an indirect fashion. For instance, in accordance with the view of Berg (1993: 23) that "the eighteenth century was much more industrial than once thought", studies on England (Saito and Shaw-Taylor forthcoming) and Spain (Marfany 2010, 2012; Sarasuà 2019) found that textiles manufacturing in the countryside during the eighteenth century was far more widespread as originally assumed in the historiography, even surpassing the nineteenth century in relative employment numbers (Sarasuà 2019; Saito and Shaw-Taylor forthcoming). Additionally, it has been argued that the widespread 18th-century domestic-based and labor-intensive hand spinning production by female and child workers in the English countryside indirectly motivated entrepreneurs and inventors in the late eighteenth-century to develop and implement steam power (Humphries 2011; Muldrew 2012; Humphries and Schneider 2018), whereas Rose (1996: 15) and Crafts and Wolf (2014: 1107, 1136) argued that the eighteenth-century rural fustian manufacture geographically overlapped with the later modern cotton factories in Lancashire, due to agglomeration and geographical lock-in effects.

Thus, although the topic of proto-industrialization produced a valuable stream of literature during the 1970s-1990s and continues to stir up debates in economic history at present, the unresolved ambiguity has gravely complicated the assessment of its explanatory power for recent studies. One reason for this ambiguity has been the lack of econometric tests of the effect of proto-industrialization on modern industrialization. Therefore, as a preliminary, though necessary, first step to determine the explanatory power of proto-industrialization, we systematically test for the effect of the location of proto-industrial activities on the location of modern industrial activities in the two largest textiles-producing regions in the nineteenth-century Low Countries: the Eastern Netherlands and Flanders, the latter encompassing the region that Mendels (1972) had put forward as his example of a proto-industrial region. As such, we do not test the micro-economic foundations on how particular companies or laborers had their roots in proto-industry. Instead, we test for the partial – though main – premise of the

[18] Taking the sum of times cited by year of Mendels (1972) as reported on the Web of Science as a reference point, it appears that the popularity of proto-industrialization even increased during the 2000-2017 period, linearly increasing from 55 times cited in 2000 to an absolute peak of 202 times cited in 2016, to a small decline in 2017 and 2018 (respectively 178 and 146 times cited).

proto-industrialization thesis that Mendels (1972: 246) put forward: whether "industry tended to locate itself […] in the regions where there had been handicraft industry before". Additionally, by comparing the empirical results for both regions, we explore the preconditions in which a successful transition from proto-industry to modern industry could take place (or not).

We introduce such a systematic empirical test for the effect of proto-industry in three respects. First, by drawing for both regions on newly developed datasets on the number of people employed in spinning and weaving for both regions on the local municipal level (Ronsijn 2015; Philips 2019), in which we can differentiate between employment in proto-industry in ca. 1850 and modern industry in ca. 1890. Second, by controlling for other economic, demographic, geographical, and institutional characteristics in 1850-1890 to isolate the effect of proto-industry on modern industry, as well as introducing a spatial error and spatial lag model to control for spatial dependence and autocorrelation. Third, we use the geographical distribution of livestock, more specifically goats and plow oxen, as an instrument for proto-industrial activities, given the association of rural proto-industrial textiles production with small-scale, part-time agricultural production (e.g. Mendels 1972: 242-243; Kriedte, Medick and Schlumbohm 1977: 38-73; Ogilvie and Cerman 1996: 1).

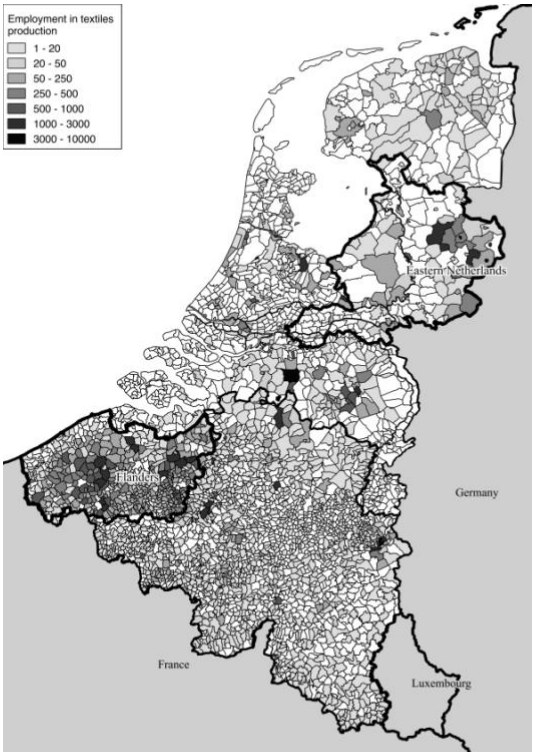
Our findings indicate for the Eastern Netherlands a positive significant effect of proto-industry on modern industry, whereas we find for Flanders an insignificant effect of proto-industry. For the explanation of the difference between the 'successful' transition in the Eastern Netherlands (i.e. where the proto-industrial heartland developed into a center of modern industry) and the 'failed' transition in Flanders (i.e. where factories developed outside the former core area of the linen industry), our evidence points to differences in the access to consumer and labor markets between both regions. Our results indicate that modern textiles factories in Flanders located near cities, where the bulk of their laborers and consumers were present. As such, we vindicate the claims of Thoen (2001) and Ronsijn (2014) that the Flemish modern textiles industry turned mostly to the urban proletariat for laborers, whereas the plentiful independent proto-industrial producers preferred to continue combining different part-time sources of income, rather than a full-time factory job. Additionally, due to English competition and the subsequent fall of crucial export outlets during the nineteenth century, most Flemish textiles were produced for closely-located cities. In the Eastern Netherlands, our evidence shows that modern factories located near population dense (but not necessarily urban) areas and places with a railway station. As such, we complement the historiography that stressed that the Eastern Netherlands faced a labor shortage, where the Dutch factory owners responded by turning to mechanization and surplus labor on the countryside (e.g. Mastboom 1996; Hendrickx 1997; Trompetter 1997). Additionally, as most Eastern Dutch textiles were bound for extra-regional markets – the Dutch western regions, the Indonesian colonies, or Germany – less advantages were in place to locate near intra-regional urban consumer markets.

The remainder of this section is structured as follows. In Section 2, we present our case-studies, followed by the description of the data in Section 3. In Section 4, we present our empirical framework, in Section 5 our results. In Section 6, we end with a brief conclusion.

3.2. Textiles production in Flanders and the Eastern Netherlands

Textile production was one of the first sectors to mechanize and as such considered to have had a catalytic effect on the industrialization process of other manufacturing sectors (e.g. Crafts and Harley 1992; Broadberry and Gupta 2009). Therefore, it is no wonder that most studies on proto-industrialization made this sector pivotal to their argumentation (e.g. Mendels 1972; Dewerpe 1985; Hudson 1986; Gullickson 1987; Kisch 1989; Vardi 1993; Terrier 1996; Zell 2004; Marfany 2012). Similar yet later than in Britain, textiles production in the Netherlands and Belgium embarked on a transition from small-scale producers to large, steam-driven factories during the nineteenth century. Turning to the spatial distribution of this sector in the Low Countries in 1896 (see figure 14), it appears that textile production was unevenly located in both countries. In Belgium, 61.24 % of all employment in textiles production was concentrated in the East and West Flanders provinces, next to the smaller clusters in Verviers and Liège. In the Netherlands, we find 43.70 % of employment in textiles production concentrated in its Eastern part, in the Overijssel and Gelderland provinces.

Figure 14. Employment in textiles production in Belgium and the Netherlands in 1896



Notes: figure denotes absolute employment numbers in textiles production.
Sources: Belgian industry census of 1896 and Dutch reconstructed industry census of 1896 (Philips 2019).

The historical roots of textiles production in Flanders and the Eastern Netherlands go back long before the nineteenth century. Linen production is argued to have obtained a prominent position in the Eastern Netherlands during the late seventeenth century (Van Bath 1961; Trompetter 1997), to be sold on national and international markets, including England. However, due to rising foreign competition, by the end of the century, most of the cloth was sold within the Republic, in particular to Holland (Trompetter 1997: 58-64, 72). In Flanders, the roots of the industry go back to the fourteenth century (Sabbe 1975; Van Bavel 2003: 1116-1126). The main destination of Flemish cloth in the eighteenth century was Spain and its colonies, until the Southern Netherlands were incorporated into the French republic, when France and the domestic market became the chief outlet (Sabbe 1975, II: 73-79, 217-223, 453-454).

Due to its part-time nature, estimates on labor force participation in proto-industrial production before the mid-nineteenth century prove hard to reconstruct. Although estimates indicate that the participation in proto-industrial activities had fallen after the last quarter of the eighteenth century due to growing international competition (Mastboom 1996: 244; Hendrickx 1997: 187-188), the scarce evidence points out that these proto-industrial activities remained widespread in both regions during the first half of the nineteenth century and that production was more widespread in Flanders compared to the Eastern Netherlands. In the Flemish rural hinterland of Oudenaarde, labor participation declined from 50-60 per cent in the 1760s to 30-40 per cent in the 1840s, although 50 per cent of the households still listed linen production as their main source of income in the linen censuses of the 1840s.[19] In the Eastern Netherlands, in Twente, 29 per cent of all household heads were active in textiles production in 1795. By the 1830s, among newly married couples, 32 per cent of the men and 11 per cent of the women were active in domestic textiles production (Hendrickx 1997: 62, 197).[20]

Notwithstanding domestic textiles production gained a prominent place in both the Eastern Netherlands and Flanders, the proto-industrial labor organization differed considerably between the two regions. In Flanders, flax was grown locally, especially in the rural hinterland around Kortrijk and Sint-Niklaas, which spinners and weavers turned into yarn and cloth from home. The Flemish spinners and weavers were predominantly independent textiles producers, working in a so-called *Kaufsystem,* although producers increasingly worked within a so-called *Verlagsystem* or putting-out system from the 1840s onwards, when merchant-entrepreneurs supplied the cotton or flaxen yarn.[21] In the Eastern Netherlands, in contrast, the *Verlagsystem* dominated already from the eighteenth century: spinning was less widespread and local weavers were dependent upon merchant-entrepreneurs for their yarn, although they did maintain their independence as cotters and cottagers (Trompetter 1997: 145). By the 1840s, textiles production in the Eastern Netherlands remained a predominantly cottage-based industry with weavers working to order of merchant-entrepreneurs, while a part of the weavers made the transition

[19] Censuses held in the 1760s showed there were 12 looms per 100 inhabitants. Assuming that each loom corresponds to one weaver, and assuming four spinners had to work for each weaver (i.e. 48 per 100 inhabitants), we can assume that 60 per cent of the total population were involved in proto-industrial textiles production. However, 48 per cent of all people working as spinners would mean virtually all the women, including the underage, which is highly unlikely. Probably, the region also imported yarn from elsewhere. In the 1840s, different linen censuses were held with divergent results (Ronsijn 2014: 98, 203-207; Ronsijn 2015: 12-14). Yet, the large numbers of people still involved in proto-industry in the 1840s were probably those for whom a return to agriculture was not an option (Ronsijn forthcoming).

[20] For 1795, we assume that the number of 29 per cent is exaggerated, as the employment in textiles production listed by Hendrickx (1997) is probably broader than the textiles employment in proto-industrial production. The 1830s numbers for the Eastern Netherlands are based upon a sample of newly married couples in the 1830s, although Hendrickx (1997) noted that for many women, no occupation was mentioned in these sources. Although the age bias in the Dutch data has to be taken into account, this points at a lower labor participation in the Eastern Netherlands compared to Flanders.

[21] Only after the 1840s, when spinners lost to competition from mechanical yarn, Flemish weavers increasingly became task workers in a *Verlagsystem* and supplied with mechanical yarn by merchant-entrepreneurs (Jacquemyns 1929; Sabbe 1975; Vandenbroeke 1979; Lamarcq 1982; Haagen 1983).

from proto-industry to semi-centralized production, in workshops where 6 to 50 looms were operative.

During the first half of the nineteenth century, mechanization and international competition put increasing pressure on these proto-industrial producers. In Flanders, most prominently in the city of Ghent, mechanization started in the early nineteenth century. After Lieven Bauwens smuggled machinery out of England to set up his mechanized cotton spinning mill around 1800, factories soon arose in the region. By 1812, approximately 10,000 factory workers were active in the city of Ghent exclusively (Périer 1885). Towards the end of the nineteenth century, modern factories expanded beyond the city of Ghent, where entrepreneurs faced increasingly higher wages and an organized labor force, into the countryside, where wages were lower and workers were more acquiescent (Verhaegen 1961: 231-234, 271, 293-294, 306-312, 316-317). In comparison, the first factories in the Eastern Netherlands arose later, during the 1830s-1850s. After the 1850s, when the Indonesian cultivation system came into place (and the Netherlands became the main supplier of textiles for Indonesia) and after a series of economic reforms ended the relative economic standstill of the Dutch economy (Van Zanden and Van Riel 2000; Smits, Horlings, Van Zanden 2000), the Eastern Netherlands emerged as the cluster of Dutch textiles factories (Mastboom 1996; Hendrickx 1997; Trompetter 1997).

With both Flanders and the Eastern Netherlands being clusters of both proto-industrial and modern industrial textiles production, the transition from proto-industry to modern industry has been the topic of discussion for both regions, in which the proto-industrial background of the Eastern Netherlands is generally viewed as more conducive for developing into modern industry compared to Flanders. For this difference, we find roughly four explanations in the historiography.

First, the aforementioned difference in terms of scale and organization of proto-industrial production between both regions. In the Eastern Netherlands, proto-industry mainly consisted of rural weavers to whom merchant-entrepreneurs put out work, whereas proto-industry in Flanders was much larger in size and putting-out far less important, as yarn was often produced locally. Second, both regions differed in the availability of labor. In comparison: whereas Flanders had 236 inhabitants per square kilometer in 1846, the Eastern Netherlands had 70 in 1849.[22] The Eastern Netherlands encompassed a sparsely populated region without any large cities, in part due to the economic emigration to more affluent regions such as Holland. As a result, factory owners in the region were confronted with labor shortages (Mastboom 1994: 52-56; 1996: 249-250). In Flanders, labor was available in abundance, although many spinners and weavers were periodically tied to agricultural activities during parts of the year, in combination with additional sources of income (Schepens 1973; Ronsijn 2014: 232-233; Ronsijn forthcoming).[23] As full-time industrial work or migration to industrializing towns in Flanders or abroad was limited among rural inhabitants, modern factories in Ghent are argued to predominantly attract labor from the urban proletariat (Gubin and Scholliers 1996: 365-366, 393-394; Thoen 2001: 142-143).[24]

Third, proto-industrial laborers in Flanders are argued to have been in a position where more modern production methods were difficult to adopt and the combination of proto-industrial labor with other sources of income appeared to offer more security (Ronsijn forthcoming). For instance, Gubin and Scholliers (1996: 365-366) argued that industrial modernization came as an external threat for Flemish proto-industrial producers, whereas Haagen (1983: 229, 234) and Van Der Wee and D'haeseleer (1996: 261) argued that Flemish weavers, working in isolation and for their own account as Kaufsystem producers, were unfamiliar with developments in market demand and inclined to resist most modernization. During the 1840s, in the face of rapid mechanization, rather than turning to other sources of income, most Flemish proto-industrial producers chose to spin and weave more, to stabilize their dwindling profits, to a point in which "[domestic spinners and weavers] could not yield any resilience to retrain or to switch employment to other sectors. Child labor and overexploitation demotivated them, hindering their capability to think about alternatives" (Vandenbroeke 1979: 173).

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[22] Numbers on Flanders were obtained from the Belgian 1846 population census, for the Eastern Netherlands we turned to the 1849 Dutch population census.

[23] Many families in the proto-industrial hinterland combined additional sources of income until the last decades of the nineteenth century, including domestic proto-industries (among which predominantly, though not exclusively, in textiles production), seasonal work in agriculture, modern industrial work, or even returning to smallholding agriculture (Schepens 1973; Gubin and Scholliers 1996: 365-366, 393-394; Thoen 2001: 142-143; Ronsijn 2014: 232-233; Ronsijn forthcoming).

[24] The only exception is the industrial area of Northern France, to which large numbers of people from Flanders migrated. Around the middle of the nineteenth century, more than a third of the population around Lille-Roubaix-Tourcoing was Belgian (Gubin and Scholliers 1996: 384).

Fourth, a substantial difference between both countries was their access to domestic and foreign markets. In the Eastern Netherlands, encompassing a sparsely populated area, most finished textiles were bound for extra-regional markets: to the Dutch western (Holland) regions or the Dutch East Indies, for which the Dutch producers had privileged access via the NHM (*Nederlandse Handelsmaatschappij*, or Dutch Trading Society) during the 1830s-1860s. Set up in 1824 as a private company (though with government support and private financial contributions of the king), the NHM had the explicit goal to reduce foreign (British) influence in the Dutch East Indies by supporting the Eastern Dutch textiles producers via import tariffs on foreign cloth for the Indonesian market.[25] In contrast, Flanders was densely populated and located near major domestic consumer centers such as Brussels and Antwerp. In addition, Flanders lost many of its export markets in the first half of the nineteenth century. Whereas England started to dominate the international market, Belgium also lost access to the Dutch colonies during the 1830s: initially the NHM turned to Ghent for its exports to the Dutch East Indies, but after Belgium left the United Kingdom of the Netherlands, the NHM shifted to the (Eastern) Netherlands (Gubin and Scholliers 384-385; Sabbe 1975, II: 453-470).

In addition, anecdotal evidence suggests that more proto-industrial producers were able to develop into modern factory entrepreneurs in the Eastern Netherlands compared to Flanders.[26] For instance, of the three largest textiles companies in the Eastern Netherlands in 1896 – *Koninklijke Stoomweverij* in Hellendoorn, *H.P. Gelderman en Zonen* in Oldenzaal, and *Ter Horst & Co* in Rijssen –, the latter two founders had a proto-industrial background, as respectively a supplier of yarn to small proto-industrial companies and an owner of a small textiles weaving company, and all three received support from the NHM.[27] In contrast, Gubin

[25] Though the NHM held no monopoly on trade, the NHM did get government support: the Dutch cloth which the NHM imported into the East Indies was exempt from duties to which foreign cloth was subject, paying comparatively high prices for cloth in order to export a stable output to the colonial market. In the course of the 1850s and 1860s, as the Eastern Dutch textile industry matured, most of this government support and import tariffs gradually vanished (Mastboom 1994: 45, 49, 52; Hendrickx 1997: 67-79).

[26] Nonetheless, in both countries, government policies aimed to modernize production while preserving existing social relations by making domestic weaving more efficient, i.e. by introducing the flying shuttle (e.g. Mastboom 1994; Gubin and Scholliers 1996). In the Netherlands, this happened through the NHM (e.g. Mastboom 1994). In Flanders, though several ‘perfecting workshops’ or *ateliers de perfectionnement* (e.g. Gubin and Scholliers 1996).

[27] The weaving company Koninklijke Stoomweverij was set up in Hellendoorn in by Godfried and Hein Salomonson, two cotton traders from Almelo, who in 1852 took over the company from Thomas Ainsworth and the Dutch Trading Society (Burgers 1954). The cotton spinning and weaving company H.P. Gelderman en Zonen was founded in 1865 by Hermannus Philippus Gelderman, the son of a German cotton spinner who migrated in 1817 to Oldenzaal. After starting his career as a supplier of yarn to spinners, Hermannus Philippus started with his

and Scholliers (1996: 390-393) argued that only a handful of the Flemish entrepreneurs had their roots in the former linen industry. Indeed, turning to the entrepreneurs of three of the largest textiles factories in the city of Ghent in 1890 – NV Florida (owned by the family de Hemptinne), NV Louisiana (owned by the families De Smet-de Naeyer) and NV Texas (owned by the family Voortman) – we find entrepreneurs without a proto-industrial background. Rather, these Flemish entrepreneurs relied on their own financial reserves, accumulated via other investments, or external financers (Debo 2015).

Thus, notwithstanding that both regions formed both the proto-industrial and industrial heartland of textiles production within their country, the effect of proto-industry on modern industry has been much debated for both regions. In the historiography, there is a consensus that the Eastern Netherlands saw a fairly smooth transition from proto-industry to modern industry, and that Flanders did not. Thus, based on the historiography for both regions, we can expect to find substantial geographical continuity in the Netherlands, and geographical discontinuity in Flanders. Yet, equipped with systematized and comparable datasets for both regions (see Section 3) and a refined empirical identification strategy (see Section 4), we put the historiography on both regions to the empirical test in Section 5.

3.3. Data on proto-industry and modern industry

As regards to data, we collect three groups of variables for both the Eastern Netherlands and Flanders on the local (municipal) level, i.e. giving us 177 observations for the Eastern Netherlands and 641 observations for Flanders. First, as dependent variables, we use employment in modern industrial spinning and weaving and the horse power of installed steam engines in approximately 1890. [28] Second, as our main independent variable, we use employment in proto-industrial spinning and weaving in approximately the 1840s-1850s. Here, we use employment numbers in the location where the labor took place, rather than the location

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father his company by supervising many local weavers and spinners to export to the Dutch Indies via the NHM (Wynand 1949). Lastly, the jute weaving company Ter Horst & Co was founded in Rijssen by Gerrit Hendrik ter Horst, who started as a brick worker but established his small linen weaving company in 1835. Although originally with little success, in 1850 his company started expanding when orders of the NHM flung his direction to produce jute bags for coffee beans (Van Nimwegen 1955).

[28] As spinning and weaving were by far the largest sub-branches of textiles production in both countries, we argue that the restriction of the data collection to these sub-branches is reasonable. Employment in spinning and weaving encompassed 83.91 % of all employment in textiles production in the Eastern Netherlands, in Flanders 88.43 % of all employment in textiles production was in spinning and weaving (exclusive of the female lace producers, who merely worked few hours to complement the family income).

of where the laborers lived.[29] Due to multiple reforms during the 1850s-1890s, a small number of municipalities were merged, for which we aggregate all data to the municipalities of 1890.[30] Third, we include a number of confounding variables, to account for potential alternative factors that might have played a role in proto-industrialization and the transition to modern industry. These include a series of economic, demographic, institutional, and geographical characteristics per municipality, for which we collect data on 1850 and 1890.

First, we collected data on employment in modern industry and horse power of installed steam engines in 1890. For 1890 in the Netherlands, we turned to the reconstruction of a Dutch industry census of 1896, based on a recently-digitized collection of municipal reports (Philips 2019). For 1890 in Belgium, we use the Belgian industry census of 1896. Both sources listed employment and horse power numbers across all municipalities and all manufacturing sectors, for which we only selected the numbers in spinning and weaving. Next, we had to exclude the employment numbers in non-modern industry. As the Dutch municipal reports of 1896 reported employment and horse power numbers at the individual factory level, we only used those numbers when the establishments listed a steam engine active in their establishment (Philips 2019). In other words: we take the use of steam engines as a proxy of modern industry. We applied this subdivision on the Flemish data, where numbers were aggregated per municipality, by keeping the employment number in a given sub-sector and a given municipality if there were steam engines registered for this given sub-sector and municipality. Although we can expect that this attribution could have misattributed some employment numbers in the Belgian census of 1896 erroneously as modern industry (or not), we can assume that the potential of such

[29] For proto-industry, the location of where the labor took place overlapped with the place of residence, as production takes place at home. Yet, for modern industry the work place and residence often deviated, as workers commute. We account for this deviation in both datasets in Section 4, by controlling for spatial autocorrelation, assuming the place of residence and workplace is spatially approximate.

[30] For the Eastern Netherlands, 3 municipalities changed borders during 1850-1890, all of which were merged in their entirety to other municipalities during 1850-1890. In Flanders, 9 municipalities changed borders (partially), 3 municipality merged in its entirety to another or new municipality, and 6 municipalities were created from splinters of existing municipalities. Yet, the number of these observations is relatively small compared to the total number of observations in both regions. For the 1890 municipalities which were created from (splinters of) multiple 1850 municipalities, we aggregated the numbers of the 1850 merged municipalities to their 1890 counterpart.

misattribution is small due to the large of number of municipal and sub-sectoral units in this census.[31]

Second, we collected data on employment in proto-industrial textiles production. For Belgium in 1850, we turned to the linen censuses of 1840 for West Flanders and 1843 for East Flanders, digitized by Ronsijn (2015).[32] Both sources present a total count of the people active in domestic weaving and spinning. For the Eastern Netherlands, we turned to the number of employees as recorded in the Condition of the Dutch Factories in 1857, a report compiled by the *Dutch Society for the Promotion of Industry* (Nederlandsche Maatschappij 1859) based on a large collection of municipal reports. As the *Condition* reported the number of employees in textiles production, without making explicitly clear whether these employees were active in proto-industrial or other types of textiles production, we had to filter out the employment in non-proto-industrial spinning and weaving. This could either be done directly, via the name of the sub-sector that often indicated the use of proto-industrial or domestic labor (or its lack of it), or indirectly, by excluding all employment numbers in a given municipality and sub-branch for which a steam engine was reported.[33]

Table 8. Employment in textiles production in the Eastern Netherlands and Belgium, differentiated across sub-sector and gender

	proto-industry (1850)	modern industry (1890)

[31] The Belgian census of industry of 1896 differentiated its employment numbers over 57 sub-sectors of weaving and spinning, differentiating across type of input product, type of finished product, or elsewise. In contrast to the Dutch census of 1896, the Belgian industry census of 1896 aggregated the employment numbers over municipal and sub-sectoral units and not across individual establishments or companies. Therefore, we can expect that our used method of filtering out the employment in non-modern industry based on the usage of steam in the sub-sectoral and municipal units would have sometimes introduced a misattribution. Yet, given the large number of sub-sectoral and municipal units, we can hypothesize that this misattribution would have been reduced to a small amount of cases. For instance, when aggregating the Dutch census of 1896 numbers across sub-sectoral and municipal units, similar to the Belgian 1896 census, we find that this method underestimated the employment in modern industry by 4.07 % compared to the exact attribution via establishment units.

[32] For comparability, we could not use the 1840 data for East Flanders. The 1840 linen census of West Flanders listed the total number of spinners and weavers. In East Flanders, it listed the number of spinning wheel and looms within families having the linen industry as their main source of income. The 1843 linen census of East Flanders does list the total number of spinners and weavers.

[33] The Dutch census of 1857 categorized employment numbers over 32 sub-sectors, differentiating across type of input products, type of finished products, organization of labor, use of steam, etc. The level of detail in the name of the sub-sector was in most cases enough to differentiate between proto-industrial and non-proto-industrial labor, as most sub-sectors indicate whether steam was used or when labor was organized in a central place. For instance, we find multiple names which indicated its use of steam, such as the sub-sectors of steam spinning factories (*stoomspinnerij*) and steam fur weaving factories (*Koninklijke Stoombontweverij*). Additionally, employment in semi-organized forms of production were indicated by names of sub-sectors such as *calicotweverij*, which implied that the weaving or spinning took place within a workshop and not in the home of the workers.

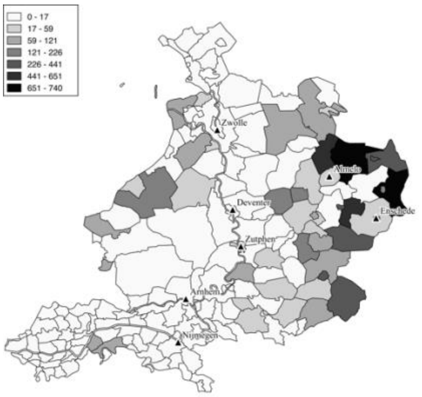
	spinning of textiles	weaving of textiles	**total**	spinning of textiles	weaving of textiles	**total**
Eastern Netherlands						
male employees	680	2.020	**2.700**	2.889	7.265	**10.154**
female employees	2.068	5.308	**7.376**	1.455	3.473	**4.928**
total	**2.748**	**7.328**	**10.076**	**4.344**	**10.738**	**15.082**
Flanders						
male employees	-	-	**-**	8.274	13.514	**21.788**
female employees	-	-	**-**	11.515	7.030	**18.545**
total	**212.566**	**50.667**	**263.233**	**19.789**	**20.544**	**40.333**

Notes: the sources for proto-industry in 1850 and modern industry in 1890 in the Eastern Netherlands differentiated by gender. Yet, whereas the statistics for Flanders on modern industry in 1890 did so as well, the statistics on proto-industry in 1850 in Flanders did not. Therefore, the gender division was not reported for this benchmark year in the above table.

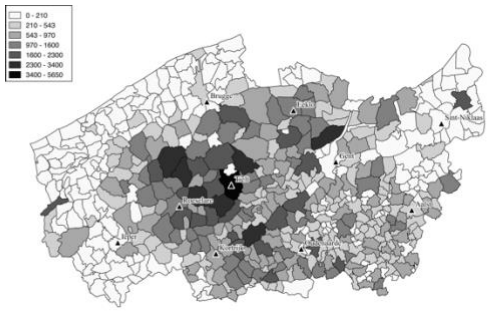
Turning to the total employment in textiles production in proto-industry and modern industry in Table 8, we find a very different picture in both regions. First, we find that the 1850-1890 period introduced in both regions a rapid shift from predominantly proto-industrial production to predominantly modern industry production. Most prominently, this seems to have applied for Flanders, which yielded higher employment numbers in spinning and weaving. Most proto-industry had disappeared by 1896, due to mechanization. For instance, by 1896, the Belgian industrial census reports about only 9.876 people left weaving flax and 8.150 weaving cotton or flax at home in Flanders. Blanchard (1906: 378-390), in his study on Flanders, wrote that these were mainly elderly people, hanging on the work they had done since their youth. Second, the nineteenth century seems to have caused a shift from a predominantly female to a predominantly male textiles production for both regions, in line with the findings of Sarasuà (2019) for Spain. In the Eastern Netherlands, proto-industrial spinning was dominated by women, whereas this is argued to have been the same for Flanders.[34] Due to the earlier mechanization of spinning, precisely this group was most vulnerable to losing their occupation.

Figure 15. Employment in textiles production in the Eastern Netherlands and Flanders

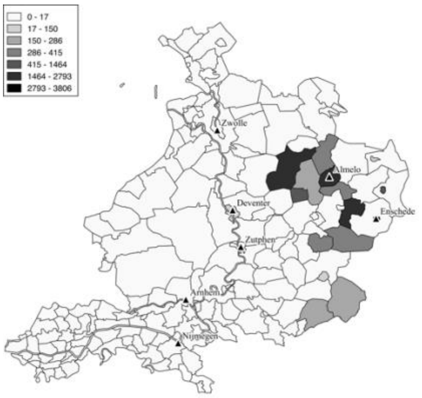
[34] On average, four spinners were considered necessary to provide the work of one weaver in Flanders, with most sources presenting weaving as a predominantly male occupation and spinning as a predominantly female occupation (Ronsijn 2014; Ronsijn 2015).



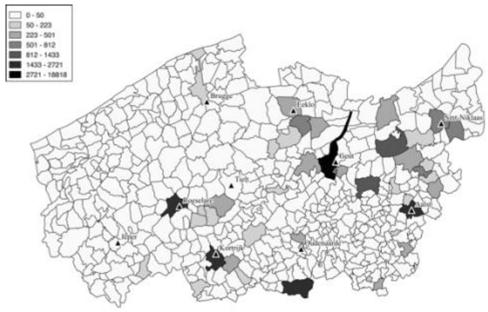
Eastern Netherlands,
employment in proto-industry (1850)



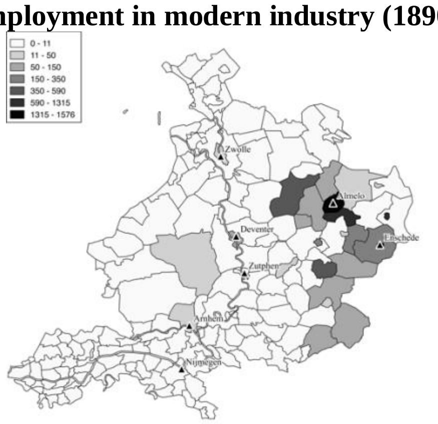
Flanders,
employment in proto-industry (1850)



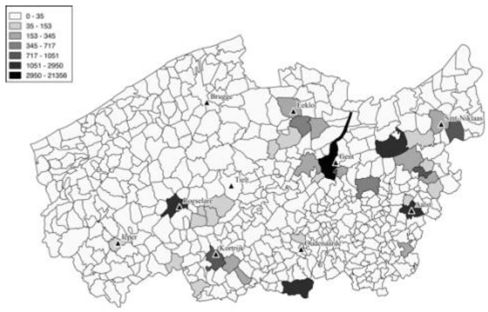
Eastern Netherlands,
employment in modern industry (1890)



Flanders,
employment in modern industry (1890)



Eastern Netherlands,
amount of horse power (1890)



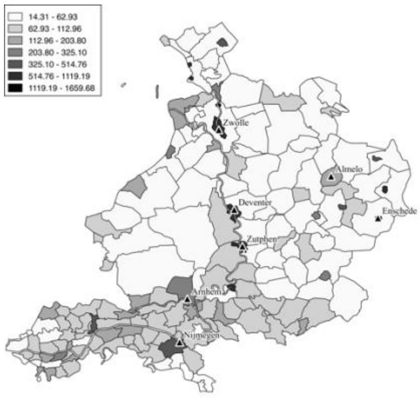
Flanders,
amount of horse power (1890)

Notes: figures denote total number of employees in spinning and weaving and the amount of horse power in installed steam engines in spinning and weaving.

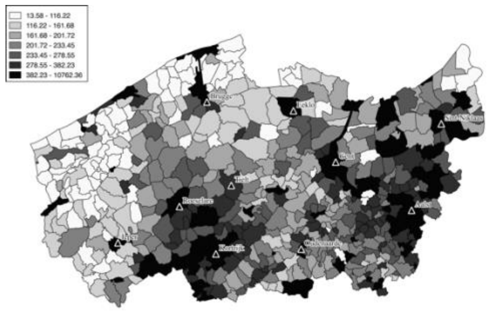
Turning to Figure 15, we notice for both regions changes in the intra-regional distribution of proto-industrial and modern industrial textiles activities. In Flanders, the proto-industrial heartland was located in inland Flanders, centered around the cities of Oudenaarde, Tielt and Eeklo. At first sight, it appears that modern textiles production expanded in Flanders outside the former core area of proto-industrial production: next to Ghent and Aalst, to the regions of Sint-Niklaas, Dendermonde and Kortrijk. In the Eastern Netherlands, proto-industrial activities were clustered in two smaller areas: the northern sandy hills of the Veluwe, to the southwest of Zwolle, and the eastern Achterhoek and Twente areas. Seemingly, modern industry in the Eastern Netherlands of 1890 deviated less from the proto-industrial areas of 1850 compared to Flanders, clustering around the cities of Enschede and Almelo and their rural hinterland. Not surprisingly, highest values for the amount of horse power were noted for both regions in places with high values of employment in modern industry.

Additionally, we include a set of confounding variables, to control for local economic, demographic, institutional, and geographical characteristics which might have influenced the transition from proto-industry to modern industry or the development of modern industry. First, the demographic characteristics. We obtained data on population density, estimated as the per square kilometer population total per municipality, captured from the Dutch 1859 and 1899 Censuses of Population and the Belgian 1846 and 1900 Censuses of Population. From the same sources, we obtained the cross-municipal mortality rate, fertility rate, and average household size. Turning to the spatial distribution of population density in Figure 16, highest values are found in the Eastern Netherlands near cities such as Deventer, Nijmegen, Arnhem, and Zwolle, or alongside the IJssel and Rhine rivers. In Flanders, population density was highest near the cities of Sint-Niklaas, Ghent and Kortrijk, and the southeastern areas. In contrast, the highest values for average household size were noted in the rural areas of both regions, in the eastern part of the Eastern Netherlands and the northwest and southeast areas of Flanders, plausibly due to the higher prevalence of extended and complex households among farmers, as found by Verduin (1972: 102) and Paping (2018: 365) for the northern Netherlands.

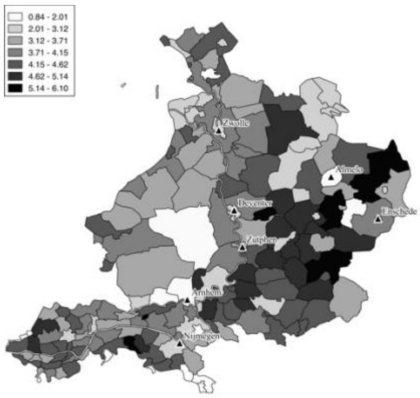
Figure 16. Population density and average household size in the Eastern Netherlands and Flanders



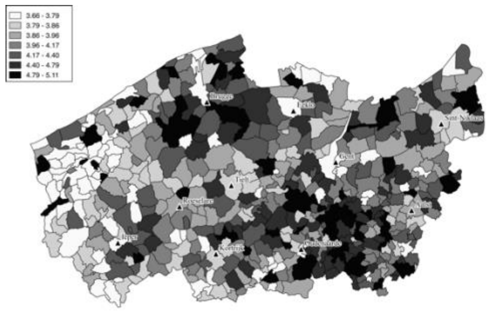
Eastern Netherlands,
population density (1890)



Flanders,
population density (1890)



Eastern Netherlands,
average household size (1890)

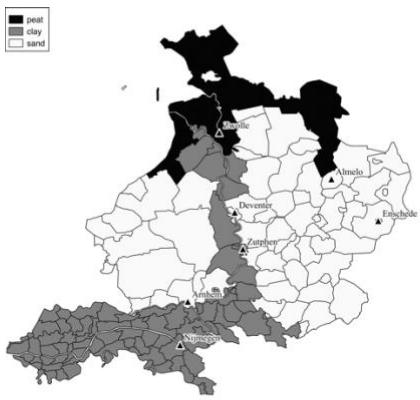


Flanders,
average household size (1890)

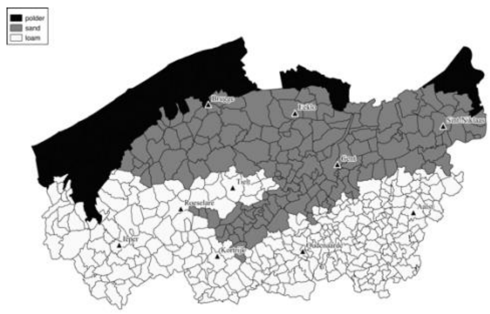
Notes: figures denote population density as total inhabitants per km^2 and average household size as the average number of members per household.

Second, for the geographical characteristics, we turned to three groups of data. First, we calculated the distance from the nearest river from the municipality center. Second, we controlled for the predominant soil type within a municipality, for which we classified all Belgian and Dutch municipalities into soil type categories, based on respectively the soil association map in Belgium and the soil type map in the Netherlands.[35] These maps categorized the municipalities of both regions in three categories of underground: sand, loam, and peat in the Eastern Netherlands, and sand, loam, and polder in Flanders (see Figure 17). In the Eastern Netherlands, the municipalities with peat reserves are found in the northern corner, clay areas in the alluvial plains alongside the IJssel, Rhine and Waal rivers, and sandy areas in the eastern Veluwe and western Achterhoek and Twente. In Flanders, the polder area is found in the north-western part of the region which borders the North Sea, sandy areas in the northern part of inland Flanders, and loamy areas in the higher-elevated southern areas. Third, we add a dummy variable when the municipality had a maritime border: the North Sea in the Flemish case or the Zuiderzee in the Eastern Dutch case.

Figure 17. Soil types in the Eastern Netherlands and Flanders



Eastern Netherlands,
soil type (1890)



Flanders,
soil type (1890)

Notes: figures denote the predominant soil type within a given municipality.

Third, for economic characteristics, as a proxy for human capital, we included data on literacy rates. In Belgium, data could be found in the population censuses of 1866 and 1900.

[35] The Dutch map is based on the Grondsoortenkaart van Nederland (2006), Wageningen University & Research-Alterra, more information via: https://www.wur.nl/nl/show/Grondsoortenkaart.htm. The Belgian map is based on the Bodemassociaties Atlas van België (1992), Brussels, more information via: http://www.geopunt.be/download?container=bodemassociatie&title=Bodemassociatiekaart. Due to the multitude of soil types in both maps, we collapsed different soil types. For the Eastern Netherlands, we collapsed this to sand *(zand*), loam (including *lichte klei*, *lichte zavel*, *zware klei* and *zware zavel*) and peat (*veen*). For Flanders, we collapsed numerical values of soil association types to sand (soil types 11-29), loam (soil types 30-60), and polder (soil types 1-10 and 70-90).

For the Netherlands, we turned to the Historical Sample of the Netherlands, which provided a vast database of marriage contracts for both the 1840 – 1860 and the 1880 – 1900 period, for which we used the ratio of signed marriage contracts in the municipality where the marriage took place as the indicator of literacy rates per municipality.[36] For the average wage rate, we used for Belgium the average daily wage from agricultural workers per municipality, as measured in the 1846 and 1895 Censuses of Agriculture. As no source exists that records wages on the municipal level for the Netherlands, we turned to the closest available indicator of local purchasing power: the 1859 and 1889 per capita *personele belasting* or tax revenue on the rental value of buildings and material goods, as recorded in the provincial reports and digitized by the Historical-Ecological Database or *Historisch-Ecologische Databank*. Additionally, we included a dummy variable when there was a bank located within the municipal boundaries.[37] Lastly, as indicators of the proximity to commercial centers from the municipal center, we assembled three indicators. First, the distance to the nearest railway line from the municipal center.[38] Second, a dummy variable if the city held city rights in 1850 and 1890, to control for the difference between city and countryside. Third, the distance to the nearest large city from the municipal center.

As illustrated in figure 18, we find for the Eastern Netherlands that the average wage rate was highest in the municipalities alongside the Rhine and IJssel rivers, potentially due to its access to the domestic and foreign markets. Similarly, in Flanders, this encapsulated the cities and their direct hinterland, with access to urban consumers, the Flemish eastern areas, with access to Antwerp via the Scheldt and Dender rivers, and Bruges and Kortrijk with access to the French market. Highest literacy rates are noted in similar areas, in Flanders around the larger cities and the north-western areas, in the Eastern Netherlands in the northern areas and alongside the IJssel and Rhine rivers.

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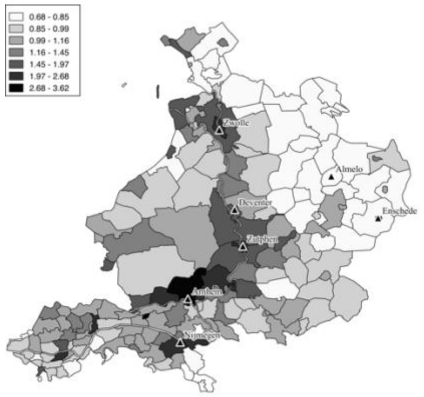
[36] We took 10 observations as a threshold for a representative sample. In the 29 municipalities (out of a total of 171 municipalities) for which the marriage records did not reach this threshold, we took the weighted average of the bordering municipalities.

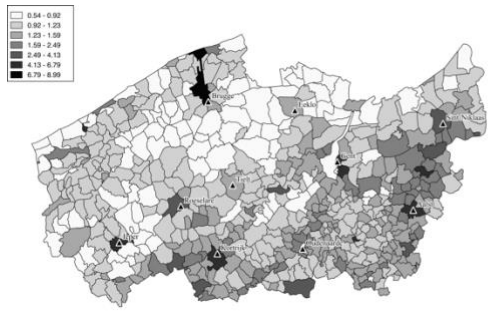
[37] For Belgium in both benchmark years, we added a dummy variable for those municipalities which the industry census of 1910 reported employment numbers in banking staff, as no data on the number of bank establishments within a municipality was available for nineteenth century Belgium. For the Netherlands, we added a dummy variable when a bank establishment was located in the municipality, for which we turned to two datasets which combined report all bank establishments located in the Netherlands in 1850 and 1898: the large banks as reported in *De Nederlandsche Bank* (2000) and the variety of smaller banks (more specifically, *spaarbanken*, *spaarkassen*, *hulpbanken*, *banken van lening,* and *boerenleenbanken*), both digitized by De Vicq and Van Bochove (2019).

[38] Railway stations were obtained from the 1:20.000 topographical maps of 1847 and 1899 for Belgium and the 1:200.000 maps of 1865 and 1899 for the Netherlands.

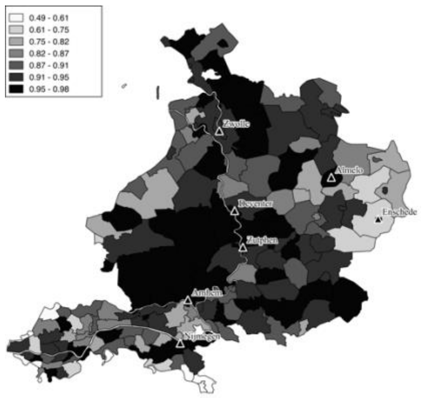
Figure 18. Average wage rate and literacy rate in the Eastern Netherlands and Flanders



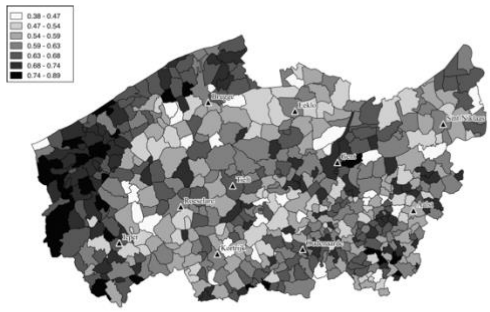
Eastern Netherlands,
average wage rate (1890)



Flanders,
average wage rate (1890)



Eastern Netherlands,
literacy rate (1890)



Flanders,
literacy rate (1890)

Notes: figures denote literacy rate and the average wage rate (for the Netherlands the per capita tax revenue on building rental value in guilders, for Flanders the average daily wage of 1fte agricultural worker in francs).

Fourth and last, we control for institutional characteristics. As studies have stressed the role that the bourgeoisie for Belgium (e.g. Polasky 1980: 209-226), which was predominantly French-speaking, and the protestant elites for the Netherlands (e.g. Trompetter 1997: 99-142) might have played for industrialization, we included respectively the share of the French-speaking population from the aforementioned Belgian population censuses,[39] and the protestant

[39] The 1846 and 1900 population census of Belgium recorded the population that could ‘speak all three official languages’ (referring to Dutch, French, and German) and the population that could speak at least ‘two official languages’. Following the assumption that the population in Dutch-speaking Flanders which was adequate in two languages would mainly encompass a population that could speak both Dutch and French, we took the numbers from the latter group as a proxy of the French-speaking population.

population share from the aforementioned Dutch population censuses.[40] As the varying distance to the capital from the municipal center might have resulted in varying degrees of political influence, we calculated the distance from the Dutch and Belgian municipal center to respectively The Hague and Brussels. Similarly, to control for political influence from lower levels of government, we introduce a dummy on the two lower administrative subdivisions in both countries: the provincial level for both the Netherlands and Belgium, and the arrondissement level for Belgium and the COROP level for the Netherlands.[41] We also added a dummy variable for when the municipalities had an international border, as the closeness of another country could have facilitated the import of new technology or improved the access to nearby labor markets.

3.4. Empirical framework

What was the role of proto-industry for the development of modern industry in the Eastern Netherlands and Flanders? To answer that question, we set out to test the effect of employment in proto-industry in ca. 1850 on two dependent variables: the employment in modern industry in ca. 1890 and the amount of horse power in ca. 1890, while controlling for the confounding factors that have been deemed important for the transition to modern industrial production. Yet, measuring this effect faces methodological challenges, as both proto-industrialization and industrialization could have been pushed by the same common factors. In order to resolve this issue of endogeneity, we take as an instrument the geographical distribution of livestock owned by small landholders, as small-scale agricultural activities on a part-time basis are often argued to have been associated with proto-industrial activities.

3.4.1. Identification strategy: instrumenting proto-industry

In the following section, we argue that livestock on small-scale landholdings is correlated with the number of people involved in proto-industrial textiles production, but not correlated with modern industrial textiles production. Due to the unavailability of a suitable common proxy of

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[40] For the protestant population share, we collapsed the population in the following religious denominations: *Nederduitsch Hervormden*, *Waalsch Hervormden*, *Remonstranten*, *Christelijk Gereformeerden*, *Doopsgezinden*, *Evangelisch Luthersen*, *Hersteld Luthersen*, and *Personen behoorende tot de Gereformeerde kerken*.

[41] In the Netherlands, this entails the COROP regions of Achterhoek, Arnhem-Nijmegen, Noord-Overijssel, Twente, Veluwe, Zuidwest-Gelderland, and Zuidwest-Overijssel. In Belgium, this entails the arrondissements of Aalst, Brugge, Dendermonde, Diksmuide, Eeklo, Gent, Ieper, Kortrijk, Oostende, Oudenaarde, Roeselare, Sint-Niklaas, Tielt, and Veurne.

livestock on small-scale landholdings for both regions,[42] we take the number of plow oxen in the Eastern Netherlands and the number of goats in Flanders as a proxy of small-scale landholdings in both regions. For the first, we turned to the livestock counts as reported in the 1860 Dutch municipal reports,[43] whereas the latter was documented in the Belgian agricultural census of 1846.

First, we assume a link between small-scale landholdings and proto-industrial textiles production. With this line of thought, we follow the studies which stressed that "proto-industrialization was practiced part time by peasants who also labored in agriculture" (Ogilvie and Cerman 1996: 6). Neither types of livestock provided inputs for modern textiles production, nor had most modern industrial workers time to perform many agricultural activities, at least not to the degree of their proto-industrial textiles producing colleagues. Yet, in both regions, proto-industrial textiles producers are documented to have combined proto-industrial weaving and spinning with agricultural activities on a part-time basis. In the Eastern Netherlands, households active in spinning and weaving most often combined these activities with operating a smallholding.[44] Similarly, in Flanders, spinners and weavers often combined proto-industries with agricultural wage labor on the holdings of large farmers (Lambrecht 2003; Vermoesen 2010; Ronsijn forthcoming: 15), or operating a small- or micro-holding (Vanhaute and Lambrecht 2011; Thoen and Soens 2015).[45]

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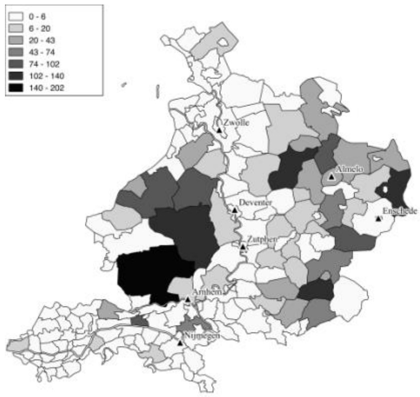
[42] In the Eastern Netherlands, goat and sheep herds were disproportionally located around the alluvial plans of the Rhine and IJssel rivers and the Veluwe sandy plains (Sneller 1951: 378), rendering this proxy inappropriate. Conversely, only 56 plow oxen were reported in the Belgian agricultural census of 1846 for Flanders, living in only 23 of all 641 municipalities in Flanders.

[43] For these municipal reports, we had to turn to archival sources. For the records of the province of Overijssel, we refer to Historisch Centrum Overijssel [Archive Historical Centre Overijssel], archive inventory 0025 Provinciaal Bestuur van Overijssel [0025 Provincial administration of Overijssel], archive items 9329-9848 Gemeenteverslagen, 1842-1936 [9329-9848 Municipal reports, 1842-1936]. For the records of the province of Gelderland, we refer to Gelders Archief [Archive Gelderland], archive inventory 0039 Gedeputeerde Staten [0039 Provincial executive of Gelderland], archive items 1182-1583 Gemeenteverslagen [1182-1583 Municipal reports].

[44] In the Eastern Netherlands, farmers, smallholders, land-poor, and landless households were active in proto-industrial work, and combined it with farming either simultaneously or switched back and forth between textiles and farming in the course of their life-cycle (Hendrickx 1997: 184-188). In Twente, "proto-industrial weaving, as well as seasonal migration or agricultural wage labor within Twente, was a means to supply the income needed to continue a peasant-like lifestyle" (Trompetter 1997: 144-145). In the Achterhoek during the nineteenth century, income from textile production often was invested in "better drainage, higher-quality seed, and animal feed". In other words: peasants "wove to improve and expand their farms" and "[w]eaving was subservient to agriculture" (Mastboom 1996: 246, 252).

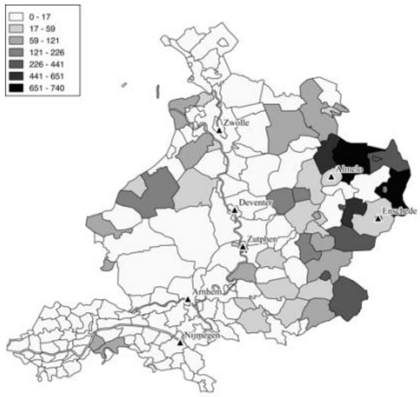
[45] Only around the middle of the nineteenth century, a considerable proportion of the Flemish population, ca. 20-25 per cent of all households, became landless, as the loss of income from their proto-industrial work prevented them from paying land rents (Ronsijn forthcoming).

Figure 19. Goats, plow oxen and employment in proto-industry (1850) in the Eastern Netherlands and Flanders

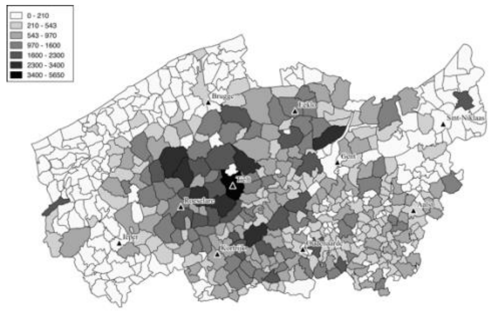


Eastern Netherlands,
number of plow oxen (1850)

Flanders,
number of goats (1850)



Eastern Netherlands,
employment in proto-industry (1850)



Flanders,
employment in proto-industry (1850)

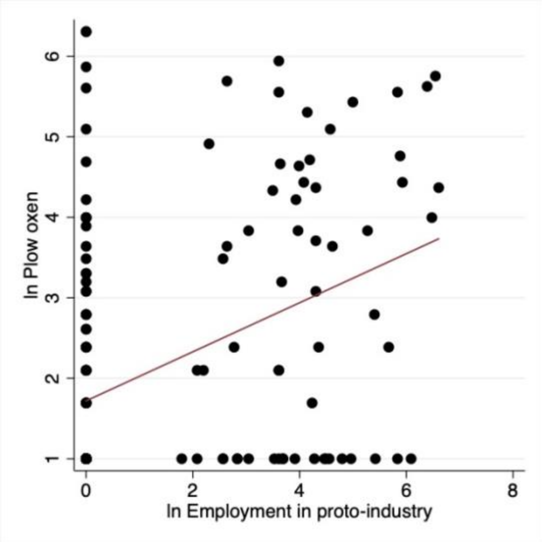
Notes: Figures on plow oxen and goats denote the absolute number of goats and plow oxen. Figures on employment in proto-industry denote total number of employees in spinning and weaving and the total number of goats and plow oxen.

Second, we assume that small-scale landholdings are proxied by the number of plow oxen in the Eastern Netherlands and the number of goats in Flanders. For both regions, little is known about the economic or social background of livestock owners. Although undoubtedly goats were also raised on large farms in Flanders, just as plow oxen on large farms in the Eastern Netherlands, we find historiographical evidence to assume that both types of livestock were predominantly kept by small landholders. For Flanders, anecdotal evidence supports the combination of domestic weaving with the keeping of goats, as goats were cheap to feed and required little to no land, ideal for small landholders (Ducpétiaux 1855: 66-68; Jacquemyns 1929: 222-223). The rare quantitative evidence provided by Thoen and Vanhaute (1999: 291) showed that in 1846, one third of all micro-farms – defined as a farm cultivating a surface of less than 0.5 hectares – kept goats. For the Eastern Netherlands, plow oxen are argued to have been associated with smallholdings as well: given their higher productivity, horses gradually replaced plow oxen during the nineteenth century (Van Zanden 1985: 27). As a result, horses were more common on large farms, whereas plow oxen were more favorable among small landholders (Van Zanden 1985: 37-38).[46] For instance, the 1825 edition of the *Statistical Description of Gelderland*, issued by the Gelderland *Commission of Agriculture*, noted that "there are certain cases in which [plow oxen] are to be preferred, for example […] on very small landholdings where there is not enough work for a single horse, or for laborers who are not wealthy enough to buy a horse" (Commissie van Landbouw 1826: 276).

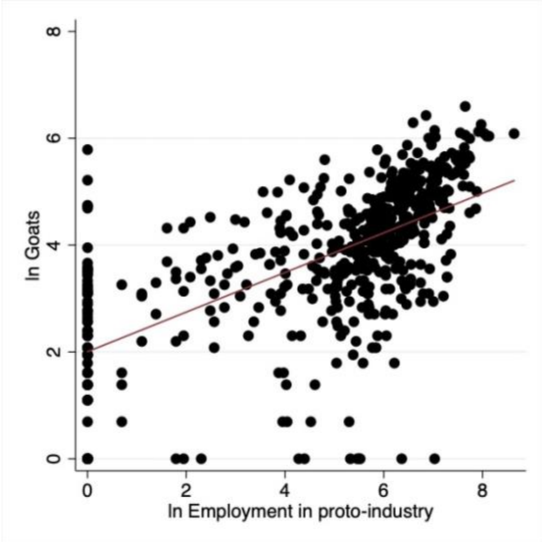
Indeed, our data indicate a strong relationship between the geographical variation in the employment in proto-industry and the number of goats in Flanders and the number of plow oxen in the Eastern Netherlands. Figure 19 illustrates the geographical overlap between the variation in the number of these types of livestock and employment in proto-industry in both regions. For Flanders, we find indeed a match between the geographical distribution of goats and employment in proto-industry, both clustering around the rural hinterland near the cities of Kortrijk, Oudenaarde, and Tielt. For the Eastern Netherlands, we find that the regions with a high prevalence of plow oxen encompassed the municipalities with high employment numbers in proto-industry, in particular the Veluwe and Twente-Achterhoek areas. Similarly, Figure 20 affirms the positive correlation between proto-industry and goats for Flanders (0.6259) and proto-industry and plow oxen for the Eastern Netherlands (0.4051).

Figure 20. Correlation between employment in proto-industry (1850) and the number of goats and plow oxen (1850)

[46] Oxen were cheaper, both in maintenance as well as taxes (Molemans and Goossens 1994: VII-VIII). Oxen were also more resistant to diseases (Schot, Lintsen, Rip and De la Bruhèze 2000: 29), making them more favorable among small landholders who preferred low costs over higher productivity.



Eastern Netherlands



Flanders

Notes: All variables are in logarithm, using ln(x+1).
Sources: see text.

Tables 9 and 10 confirm the statistically significant relationship between the number of employees in proto-industry and the number of goats and plow oxen for both regions. 39 per cent of the variation of employment in proto-industry in Flanders is explained by the geographical variation in the number of goats (see Column 1 of Table 10). For the Eastern Netherlands, the geographical variation in the number of plow oxen explain 16 per cent (see Column 1 of Table 9). The coefficient declines mildly once controlled for the economic (Column 2), demographic (Column 3), institutional (Column 4), and geographical (Column 5) characteristics in 1850, but the effect remains significant at the 1 % level, in both regions. Additionally, the effect remains significant once controlled for spatial autocorrelation (Columns 6-7).

Table 9. Employment in proto-industry (1850) and plow oxen (1850) in the Eastern Netherlands

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS (Error)	(7) OLS (Lag)
	ln Employment in proto-industry (1850)						
ln Plow oxen	0.538***	0.660***	0.696***	0.503***	0.449***	0.385***	0.363***
	(0.111)	(0.118)	(0.102)	(0.120)	(0.125)	(0.0956)	(0.0950)
ln Average wage rate		0.0650	0.0384	-0.0580	-0.0767	0.0884	0.151
		(0.211)	(0.198)	(0.191)	(0.184)	(0.178)	(0.178)
Literacy rate		-0.0319	-0.0332	-0.0228	-0.0163	-0.00868	-0.00322
		(0.0265)	(0.0252)	(0.0229)	(0.0221)	(0.0218)	(0.0217)
Presence of railway station		-3.788***	-3.760***	-2.437***	-2.461***	-2.043**	-2.080**
		(0.458)	(1.101)	(0.461)	(0.523)	(0.941)	(0.927)
Presence of bank		-0.0355	-0.344	-0.158	-0.173	0.00462	-0.0987
		(0.671)	(0.644)	(0.591)	(0.539)	(0.538)	(0.530)
Large city		1.530***	1.163**	0.686	0.517	0.532	0.601
		(0.462)	(0.455)	(0.515)	(0.518)	(0.414)	(0.409)
ln Distance to large city		0.144	0.0632	0.0116	-0.0161	-0.135	-0.129
		(0.223)	(0.228)	(0.218)	(0.214)	(0.204)	(0.201)
ln Population density			0.153	0.205	0.185	0.0539	0.0243
			(0.224)	(0.206)	(0.204)	(0.193)	(0.191)
Mortality rate			36.32	43.37	22.85	16.18	18.39
			(36.04)	(30.04)	(30.29)	(31.16)	(30.72)
Fertility rate			-37.04	-7.881	8.442	6.635	5.331
			(25.31)	(22.40)	(24.10)	(24.36)	(24.07)
ln Average household size			-0.921**	-0.799**	-0.930***	-0.630*	-0.565
			(0.405)	(0.353)	(0.327)	(0.379)	(0.375)
Protestant population share				-8.33e-05	-0.0329	-0.287	-0.210
				(0.466)	(0.471)	(0.410)	(0.401)
ln Distance to capital				3.208***	2.802***	3.567***	5.595***
				(0.851)	(0.976)	(0.943)	(1.123)
International border				0.874	0.779	0.258	0.168
				(0.548)	(0.579)	(0.431)	(0.427)
NUTS2 (province) level				0.443	0.126	0.462	0.449
				(0.476)	(0.481)	(0.436)	(0.430)
NUTS3 (COROP) level				0.190*	0.125	0.0703	0.0703
				(0.115)	(0.119)	(0.103)	(0.102)
Soil type (loam)					0.948	0.926*	0.884
					(0.616)	(0.560)	(0.553)
Soil type (sand)					1.101**	1.034**	0.964**
					(0.532)	(0.466)	(0.460)
Maritime border					0.885	1.331***	1.140**
					(0.617)	(0.502)	(0.486)
Access to a river					-0.677*	-0.678**	-0.697**
					(0.370)	(0.306)	(0.302)
Constant	1.286***	3.499	8.414**	-33.23***	-27.19**	-36.95***	-61.10***
	(0.244)	(3.127)	(3.608)	(12.31)	(13.32)	(12.68)	(14.67)
R-squared	0.164	0.312	0.348	0.459	0.497		
Squared correlation						0.461	0.548
Lambda/Rho coefficient						.000567	-.112367
p-value						0.006	0.000
Wald test						7.628	18.823
p-value						0.006	0.000
Likelihood ratio test						13.188	17.852
p-value						0.000	0.000
Lagrange multiplier test						1.288	13.197
p-value						0.256	0.000
Observations	177	177	177	177	177	177	177

Notes: All variables are in logarithm, using ln(x+1), except for percentage values and dummy variables. Distances are expressed in kilometers. The variables concerning soil type (sand/loam) introduce dummies for the predominant soil types in the municipality, excluding *Peat* as a dummy to avoid collinearity. T-statistics are reported in brackets; standard errors are robust to control for heteroscedasticity. The asterisks denote significance levels, respectively for *** p<0.01, ** p<0.05, and * p<0.1. Columns (6) and (7) were calculated with the STATA commands for spatial regressions of Pisati (2001), constructing a binary spatial matrix with the distance band set at the smallest maximum distance between spatial units.

Table 10. Employment in proto-industry (1850) and goats (1850) in Flanders

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS (Error)	(7) OLS (Lag)
	ln Employment in proto-industry (1850)						
ln Goats	1.057***	1.042***	0.799***	0.793***	0.659***	0.625***	0.638***
	(0.0676)	(0.0762)	(0.0562)	(0.0752)	(0.0753)	(0.0554)	(0.0540)
ln Average wage rate		-0.447***	-0.626***	-0.488***	-0.253**	-0.123	-0.0813
		(0.163)	(0.131)	(0.119)	(0.123)	(0.126)	(0.131)
Literacy rate		-2.563***	-2.304***	-2.379***	-2.211***	-2.310***	-1.603***
		(0.727)	(0.627)	(0.566)	(0.578)	(0.570)	(0.562)
Presence of railway station		0.0936	0.0607	-0.00717	-0.0850	-0.0196	-0.0814
		(0.259)	(0.216)	(0.231)	(0.224)	(0.190)	(0.191)
Presence of bank		-0.568**	-0.663***	-0.555**	-0.651**	-0.511**	-0.528**
		(0.262)	(0.242)	(0.244)	(0.254)	(0.216)	(0.216)
Large city		-0.898*	-1.449***	-1.265**	-0.761	-0.825**	-0.824**
		(0.511)	(0.357)	(0.582)	(0.601)	(0.324)	(0.320)
ln Distance to large city		0.0635	0.0674	0.0639	0.0970	0.110***	0.102***
		(0.0718)	(0.0450)	(0.0732)	(0.0716)	(0.0395)	(0.0390)
ln Population density			0.754***	0.587***	0.412***	0.405***	0.351***
			(0.104)	(0.150)	(0.148)	(0.0976)	(0.100)
Mortality rate			-12.83	-8.529	-9.296	-7.423	-1.965
			(11.17)	(11.06)	(9.635)	(9.666)	(9.899)
Fertility rate			-44.23***	-23.70**	-13.95	-17.78*	-4.636
			(10.56)	(11.44)	(10.42)	(9.962)	(9.716)
ln Average household size			0.308**	0.210	0.252*	0.166	0.0910
			(0.132)	(0.149)	(0.139)	(0.118)	(0.119)
French-speaking population share				0.0699	-0.0693	0.452	-0.108
				(0.350)	(0.345)	(0.459)	(0.455)
ln Distance to capital				0.282	0.284	-0.0306	-0.360
				(0.264)	(0.272)	(0.0654)	(0.273)
International border				-0.533	-0.328	0.178	0.172
				(0.335)	(0.323)	(0.236)	(0.247)
NUTS2 (province) level				0.513*	0.636**	1.276***	0.732***
				(0.262)	(0.248)	(0.265)	(0.280)
NUTS3 (COROP) level				-0.138***	-0.117***	-0.148***	-0.00562
				(0.0381)	(0.0377)	(0.0338)	(0.0373)
Soil type (loam)					1.606***	1.330***	1.231***
					(0.356)	(0.233)	(0.262)
Soil type (sand)					1.941***	1.726***	1.633***
					(0.341)	(0.256)	(0.258)
Maritime border					-1.777***	-1.443***	-1.567***
					(0.309)	(0.357)	(0.358)
Access to a river					-0.111	-0.148	-0.143
					(0.136)	(0.129)	(0.129)
Constant	0.850***	3.418***	1.072	-1.613	-3.755	-3.414***	0.823
	(0.302)	(1.079)	(0.706)	(2.864)	(3.004)	(0.464)	(2.769)
R-squared	0.392	0.464	0.568	0.620	0.655		
Squared correlation						0.642	0.678
Lambda/Rho coefficient						-.0178952	.0015661
p-value						0.012	0.000
Wald test						6.287	39.093
p-value						0.012	0.000
Likelihood ratio test						50.576	37.756
p-value						0.000	0.000
Lagrange multiplier test						0.635	38.718
p-value						0.426	0.000
Observations	641	641	641	641	641	641	641

Notes: All variables are in logarithm, using ln(x+1), except for percentage values and dummy variables. Distances are expressed in kilometers. The variables concerning soil type (sand/loam) introduce dummies for the predominant soil types in the municipality, excluding *Polder* as a dummy to avoid collinearity. T-statistics are reported in brackets; standard errors are robust to control for heteroscedasticity. The asterisks denote significance levels, respectively for *** p<0.01, ** p<0.05, and * p<0.1. Columns (6) and (7) were calculated with the STATA commands for spatial regressions of Pisati (2001), constructing a binary spatial matrix with the distance band set at the smallest maximum distance between spatial units.

Table 11. Employment in modern industry (1890) and plow oxen (1850) in the Eastern Netherlands

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	OLS	OLS	OLS	OLS	OLS (Error)	OLS (Lag)
	ln Employment in modern industry (1890)						
Goats per capita	0.0997**	0.0398	0.0841*	0.0348	0.00997	0.0135	0.0139
	(0.0432)	(0.0428)	(0.0477)	(0.0464)	(0.0473)	(0.0440)	(0.0429)
ln Average wage rate		-0.906***	-1.078***	-0.271	-0.299	0.0579	0.0826
		(0.345)	(0.352)	(0.341)	(0.361)	(0.351)	(0.339)
Literacy rate		0.389	-0.627	-1.177	-1.176	-0.255	-0.219
		(1.477)	(1.614)	(1.365)	(1.371)	(1.455)	(1.412)
Presence of railway station		0.979***	0.922***	0.677**	0.524**	0.585**	0.644**
		(0.309)	(0.303)	(0.272)	(0.263)	(0.265)	(0.259)
Presence of bank		-0.000303	-0.0634	0.0634	-0.119	-0.0420	-0.0285
		(0.496)	(0.359)	(0.433)	(0.437)	(0.325)	(0.317)
Large city		0.873	0.0167	-0.314	-0.338	-0.393	-0.343
		(0.533)	(0.434)	(0.430)	(0.434)	(0.383)	(0.373)
ln Distance to large city		0.0275	0.257	0.435**	0.411**	0.260	0.218
		(0.233)	(0.213)	(0.196)	(0.191)	(0.197)	(0.193)
ln Population density			0.614***	0.554**	0.532**	0.386**	0.347*
			(0.217)	(0.218)	(0.213)	(0.192)	(0.187)
Mortality rate			1.483	1.495	0.805	1.102	1.301
			(1.594)	(1.115)	(1.055)	(1.380)	(1.346)
Fertility rate			-16.97	5.931	-6.043	-2.815	-0.244
			(22.54)	(18.69)	(18.54)	(20.53)	(20.04)
ln Average household size			-0.466***	-0.461**	-0.591***	-0.627***	-0.622***
			(0.166)	(0.206)	(0.214)	(0.148)	(0.144)
Protestant population share				0.342	-0.0369	0.201	0.0148
				(0.439)	(0.464)	(0.445)	(0.430)
ln Distance to capital				2.254**	2.014**	2.944***	5.026***
				(0.886)	(0.863)	(0.915)	(1.079)
International border				-0.0616	-0.196	-0.621	-0.607
				(0.637)	(0.661)	(0.420)	(0.405)
NUTS2 (province) level				-0.347	-0.584	-0.262	-0.273
				(0.440)	(0.429)	(0.413)	(0.406)
NUTS3 (COROP) level				0.164*	0.100	0.0444	0.0118
				(0.0940)	(0.0985)	(0.0998)	(0.0996)
Soil type (loam)					1.004	1.058**	1.148**
					(0.611)	(0.531)	(0.518)
Soil type (sand)					0.955*	0.875*	0.865**
					(0.552)	(0.452)	(0.441)
Maritime border					-0.393	0.0415	-0.117
					(0.346)	(0.482)	(0.460)
Access to a river					-0.649	-0.616**	-0.609**
					(0.400)	(0.304)	(0.297)
Constant	1.282***	0.562	1.486	-23.43*	-18.60*	-28.05**	-51.59***
	(0.157)	(1.430)	(2.220)	(11.89)	(10.94)	(11.73)	(13.38)
R-squared	0.026	0.161	0.247	0.351	0.385		
Squared correlation						0.340	0.463
Lambda/Rho coefficient						.0007282	-.0172452
p-value						0.014	0.000
Wald test						6.085	24.468
p-value						0.014	0.000
Likelihood ratio test						13.780	22.860
p-value						0.000	0.000
Lagrange multiplier test						1.983	14.457
p-value						0.159	0.000
Observations	177	177	177	177	177	177	177

Notes: All variables are in logarithm, using ln(x+1), except for percentage values and dummy variables. Distances are expressed in kilometers. The variables concerning soil type (sand/loam) introduce dummies for the predominant soil types in the municipality, excluding *Peat* as a dummy to avoid collinearity. T-statistics are reported in brackets; standard errors are robust to control for heteroscedasticity. The asterisks denote significance levels, respectively for *** p<0.01, ** p<0.05, and * p<0.1. Columns (6) and (7) were calculated with the STATA commands for spatial regressions of Pisati (2001), constructing a binary spatial matrix with the distance band set at the smallest maximum distance between spatial units.

Table 12. Employment in modern industry (1890) and goats (1850) in Flanders

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS (Error)	(7) OLS (Lag)
	ln Employment in modern industry (1890)						
ln Goats	0.150***	0.0520	-0.0158	-0.00475	0.00975	0.0923*	0.0131
	(0.0404)	(0.0449)	(0.0464)	(0.0532)	(0.0587)	(0.0531)	(0.0538)
ln Average wage rate		0.478*	0.490***	0.318	0.227	-0.113	0.233
		(0.266)	(0.156)	(0.292)	(0.302)	(0.142)	(0.175)
Literacy rate		-0.00186	0.00587	0.0117*	0.00975	0.0106	0.00948
		(0.00618)	(0.00766)	(0.00686)	(0.00679)	(0.00667)	(0.00780)
Presence of railway station		0.395***	0.282**	0.249**	0.215*	0.299**	0.218*
		(0.125)	(0.124)	(0.120)	(0.119)	(0.120)	(0.122)
Presence of bank		0.626**	0.421**	0.412	0.432	0.376**	0.421**
		(0.296)	(0.206)	(0.324)	(0.322)	(0.190)	(0.204)
Large city		0.948*	0.816***	0.863	0.755	0.922***	0.756***
		(0.550)	(0.280)	(0.546)	(0.543)	(0.275)	(0.284)
ln Distance to large city		-0.283***	-0.241***	-0.243***	-0.253***	-0.276***	-0.254***
		(0.0821)	(0.0392)	(0.0812)	(0.0802)	(0.0374)	(0.0384)
ln Population density			0.296***	0.303***	0.328***	0.169**	0.324***
			(0.0927)	(0.109)	(0.116)	(0.0805)	(0.0989)
Mortality rate			0.0202	0.0235	0.00712	-0.00933	0.00668
			(0.0540)	(0.0387)	(0.0371)	(0.0521)	(0.0534)
Fertility rate			1.608	2.151	1.367	-0.331	1.460
			(2.131)	(1.554)	(1.587)	(1.627)	(2.180)
ln Average household size			0.00718	0.00872	0.00739	0.0138	0.00751
			(0.0192)	(0.0371)	(0.0358)	(0.0186)	(0.0188)
French-speaking population share				0.356	0.276	0.290	0.286
				(0.480)	(0.472)	(0.302)	(0.308)
ln Distance to capital				-0.00714	0.0230	0.127*	0.0198
				(0.277)	(0.271)	(0.0709)	(0.240)
International border				-0.202	-0.225	-0.253	-0.244
				(0.225)	(0.224)	(0.185)	(0.214)
NUTS2 (province) level				-0.245	-0.276	-0.339*	-0.279
				(0.259)	(0.255)	(0.184)	(0.259)
NUTS3 (COROP) level				-0.00780	-0.0212	-0.0341	-0.0288
				(0.0304)	(0.0311)	(0.0208)	(0.0336)
Soil type (loam)					-0.0304	0.193	-0.00457
					(0.151)	(0.171)	(0.212)
Soil type (sand)					-0.294*	-0.0211	-0.262
					(0.159)	(0.221)	(0.229)
Maritime border					-0.426	-0.385	-0.441
					(0.265)	(0.330)	(0.349)
Access to a river					0.341***	0.364***	0.335***
					(0.119)	(0.109)	(0.120)
Constant	-0.0802	0.274	-3.222*	-2.569	-2.059	0.100	-1.914
	(0.135)	(1.712)	(1.653)	(3.857)	(3.753)	(0.331)	(3.348)
R-squared	0.017	0.391	0.403	0.417	0.427		
Squared correlation						0.410	0.427
Lambda/Rho coefficient						-.0681385	-.0009456
p-value						0.000	0.651
Wald test						55.503	0.204
p-value						0.000	0.651
Likelihood ratio test						51.552	0.204
p-value						0.000	0.651
Lagrange multiplier test						1.577	0.125
p-value						0.209)	0.724
Observations	641	641	641	641	641	641	641

Notes: All variables are in logarithm, using ln(x+1), except for percentage values and dummy variables. Distances are expressed in kilometers. The variables concerning soil type (sand/loam) introduce dummies for the predominant soil types in the municipality, excluding *Polder* as a dummy to avoid collinearity. T-statistics are reported in brackets; standard errors are robust to control for heteroscedasticity. The asterisks denote significance levels, respectively for *** p<0.01, ** p<0.05, and * p<0.1. Columns (6) and (7) were calculated with the STATA commands for spatial regressions of Pisati (2001), constructing a binary spatial matrix with the distance band set at the smallest maximum distance between spatial units.

Additionally, the validity of using goats and plow oxen as an instrument for employment in proto-industry is increased by the insignificant correlation of both types of livestock with employment in modern industry in 1890. Tables 11 and 12 illustrate a weak effect of the number of goats and plow oxen on employment in modern industry, turning insignificant for both regions once controlled for the economic, demographic, institutional, and geographical characteristics in 1890.

3.4.2. Model for testing the effect of proto-industry

For our analysis, we estimate the effect of proto-industry in 1850 on modern industry in 1890:

$$MI_i = \beta_1 + \beta_2\, PI_i + \beta_3\, X'_i + \varepsilon_i \qquad \textbf{(5)}$$

where we explain our independent variable MI_i or the number of horse power or employment in modern industry in 1890 in region $_i$. PI_i denotes our most important independent variable: employment in proto-industrial production in 1850 in region $_i$. X'_i denotes a vector of independent variables: our geographical, economic, demographic and institutional characteristics of region $_i$. Here, we control separately for the vector of control variables in 1850 and 1890. ε is the error term.

Yet, as we are dealing with spatial data, we can expect that the spatial proximity among the observations could inhibit a disruptive effect on our estimates. In particular, we can expect spatial dependence and autocorrelation, i.e. that observations which are spatially close tend to be more similar than observations which are spatially distant. Therefore, we expand the main equation by addressing the two most commonly considered types of spatial dependence: a spatial autoregressive process in the error term and a spatial autoregressive process in the outcome variable (Pisati 2001; Drukker, Prucha and Raciborski 2013). Therefore, we introduce a spatial error model:

$$MI_i = \beta_1 + \beta_2\, PI_i + \beta_3\, X'_i + \beta_4\, W\, \xi + \varepsilon_i \qquad \textbf{(6)}$$

where we introduce with W a spatial weights matrix and with ξ a vector of spatial errors. Additionally, we introduce a spatial lag model:

$$MI_i = \beta_1 + \beta_2\, PI_i + \beta_3\, X'_i + \beta_4\, \rho\, W\, MI_i + \varepsilon_i \qquad \textbf{(7)}$$

in which ρ denotes the spatial autoregressive parameter. As such, the spatial error model treats space as a problem, in which we expect that the standard model is erroneously specified due to spatial dependence among our observations and controls for a vector of homoscedastic and uncorrelated errors to account for this problem. In contrast, the spatial lag model expects a spatial dependence among our independent variable, the spatial distribution of modern industry, and puts a solution forward by adding the spatial lag of the dependent variable as an additional independent variable.

Additionally, we instrument the employment in proto-industrial production in 1850 in region $_i$ by the population of livestock:

$$PI_i = ø_1 L_i + ø_2 X'_i + \mu_i \quad \textbf{(8)}$$

where L_i denotes the livestock population – goats for Flanders, plow oxen for the Eastern Netherlands – in region $_i$ and X'_i is a set of control variables. Lastly, μ_i is the error term.

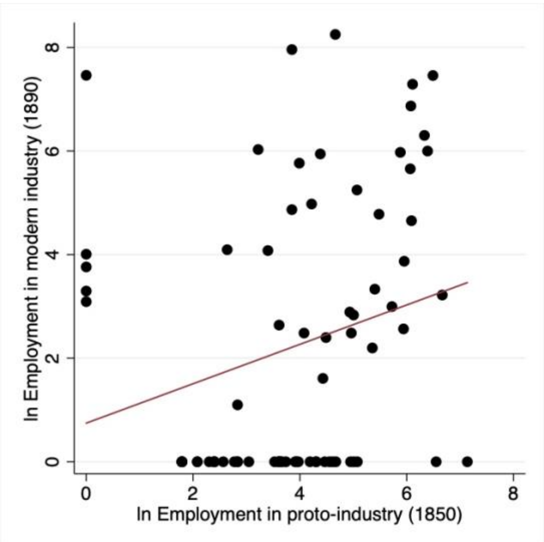
3.5. Results for the effect of proto-industry on modern industry

Turning to the effect of proto-industry on modern industry, we test for the effect of employment in proto-industry (1850) on employment in modern industry (1890) and horse power of installed steam engines (1890) in both regions, while controlling for the additional control variables. We report the effect on employment in modern industry (1890) in Tables 13 and 14 and the effect on and horse power of installed steam engines (1890) in Tables 15 and 16. In each table, we report the unconditional OLS estimation (Column 1), after which we control for the economic (Column 2), demographic (Column 3), institutional (Column 4), and geographical (Column 5) characteristics in 1850. Additionally, we introduce the vector of spatial errors (Column 6) and the spatial autoregressive parameter (Column 7). We repeat the OLS estimation for the economic, demographic, institutional, and geographical characteristics in 1890 (Column 8), again with including the spatial error (Column 9) and spatial lag (Column 10) parameters. We introduce the IV estimation in addition to the economic, demographic, institutional, and geographical characteristics in 1850 (Columns 11-13) and the characteristics in 1890 (Columns 14-16). For the discussion of the results throughout the remainder of this section, we focus on the results as reported in Column (16), as this concerns the most fully-specified version of the model and should thus present the most robust results.

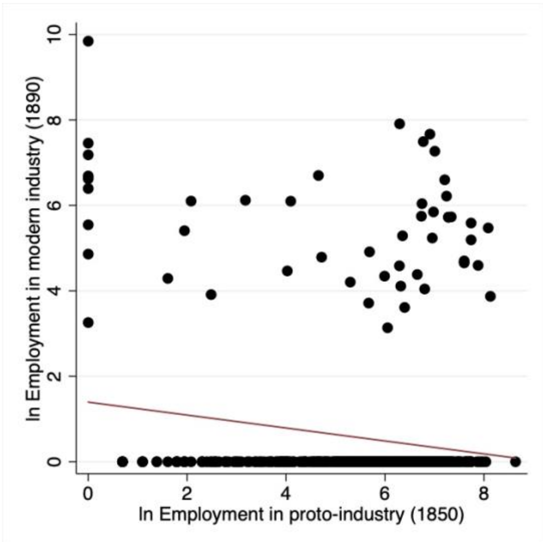
Table 13 presents a statistically significant positive effect of employment in proto-industry on employment in modern industry in the Eastern Netherlands. When we control for the additional independent variables in 1850 and 1890, as well as the vector of spatial errors and the spatial autoregressive parameter, the coefficient declines mildly but remains statistically significant. Turning to the instrumental variable regressions, our main explanatory variable remains statistically significant once we instrument proto-industry with the number of plow oxen. Additionally, the F-statistics indicate that our chosen instrument is strong. These findings suggest a strong causal relationship, in which a single standard-deviation increase in the log of proto-industrial employment in 1850 increases the log of modern industrial employment laborers by a standard deviation of 0.460 (see Column 16 of Table 13). In contrast, for Flanders (Table 14), we find an insignificant effect for proto-industry on modern industry, which turns in certain specifications even into a negative significant effect when introducing the spatial error and spatial lag model (see Columns 6-7 of Table 14). As such, our results confirm the weak, negative correlation (-0.0135) between employment in proto-industry and modern industry in Flanders but a moderate, positive correlation (0.4775) between both for the Eastern Netherlands (see Figure 21).

Figure 21. Correlation between employment in proto-industry (1850) and respectively employment in modern industry (1890) and installed steam engines (1890)

employment in modern industry (1890)

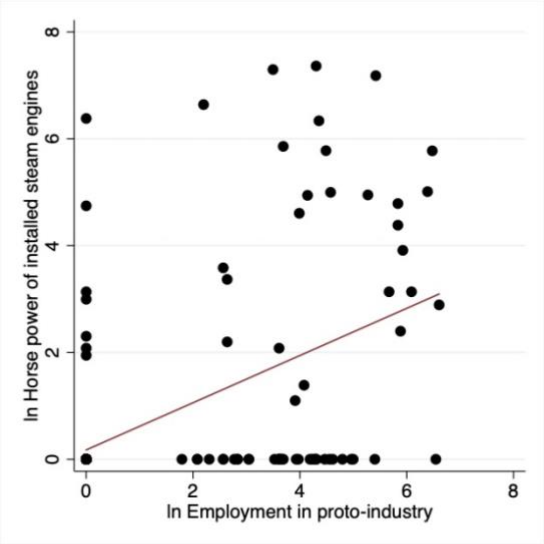


Eastern Netherlands

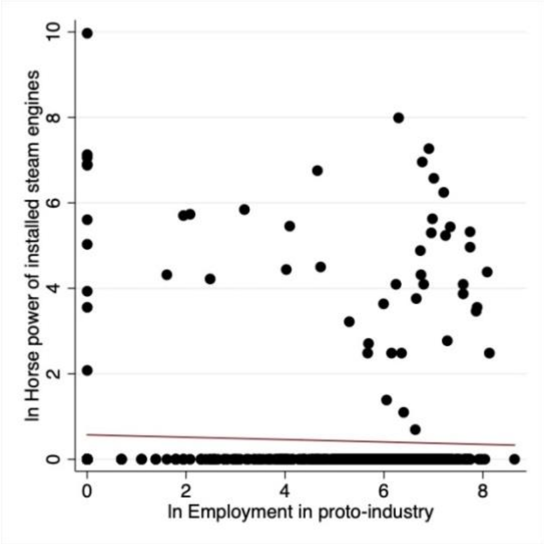


Flanders

horse power of installed steam engines (1890)



Eastern Netherlands



Flanders

Notes: All variables are in logarithm, using ln(x+1).
Sources: see text.

In Tables 15 and 16, we test for the effect of employment in proto-industry in 1850 on the total amount of horse power by installed steam engines in 1890. Just as for the effect on employment in modern industry (see Table 13), Table 15 affirms the positive significant effect of proto-industry in the Eastern Netherlands. Again, the effect remains significant, once controlled for the additional control variables, the vector of spatial errors, and the spatial autoregressive parameter. Once instrumented with the number of plow oxen, we find that a single standard-deviation in the log of proto-industrial employment in 1850 increases the log of amount of horse power by installed steam engines by 0.467 standard-deviations (see Column 16 of Table 16), a slightly higher number as for the effect on employment in modern industry (see Column 16 of Table 14). In Flanders, as for the effect on employment in modern industry (see Table 14), the effect of proto-industry on steam power is largely insignificant in Table 16: the effect becomes significantly negative at the 5 percent level once controlled for the control variables in 1850 (see Columns 8-10 of Table 16), but turns insignificant once employment in proto-industry is instrumented by the number of goats (see Columns 11-16 of Table 16).

Table 13. Effect of proto-industry (1850) on employment in modern industry (1890) in the Eastern Netherlands

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	IV	IV	IV	IV	IV	IV
						(Error)	(Lag)		(Error)	(Lag)		(Error)	(Lag)		(Error)	(Lag)
	ln Employment in modern industry (1890)															
ln Employment in proto-industry (1850)	0.424***	0.349***	0.381***	0.326***	0.267***	0.265***	0.173**	0.293***	0.236***	0.217***	0.690***	0.688***	0.524***	0.498**	0.706***	0.460***
	(0.0887)	(0.0923)	(0.0886)	(0.0893)	(0.0971)	(0.0724)	(0.0757)	(0.0954)	(0.0697)	(0.0674)	(0.239)	(0.155)	(0.145)	(0.257)	(0.141)	(0.129)
ln Average wage rate		-0.320	-0.353	0.0240	0.0377	0.0459	0.160	-0.0368	0.185	0.0976	-0.00671	-0.0265	0.0472	0.140	0.251	0.179
		(0.325)	(0.323)	(0.316)	(0.162)	(0.175)	(0.173)	(0.346)	(0.339)	(0.323)	(0.193)	(0.194)	(0.184)	(0.408)	(0.386)	(0.352)
Literacy rate		0.660	-0.336	-0.765	0.00691	0.00731	0.0219	-0.818	-0.206	-0.467	0.0108	0.00766	0.0148	-0.569	-0.330	-0.388
		(1.357)	(1.311)	(1.253)	(0.0232)	(0.0225)	(0.0223)	(1.267)	(1.409)	(1.355)	(0.0247)	(0.0247)	(0.0236)	(1.491)	(1.581)	(1.447)
Presence of railway station		0.788***	0.713***	0.543**	-0.264	-0.297	-0.587	0.442*	0.505**	0.590**	0.369	0.527	0.0858	0.378	0.362	0.325
		(0.273)	(0.266)	(0.244)	(0.416)	(0.953)	(0.930)	(0.242)	(0.255)	(0.250)	(1.098)	(1.068)	(1.007)	(0.278)	(0.288)	(0.266)
Presence of a bank		-0.245	-0.374	-0.225	0.141	0.188	0.122	-0.302	-0.213	-0.201	0.180	0.303	0.128	-0.424	-0.528	-0.395
		(0.438)	(0.395)	(0.392)	(0.759)	(0.565)	(0.540)	(0.390)	(0.316)	(0.306)	(0.610)	(0.611)	(0.577)	(0.361)	(0.364)	(0.332)
Large city		0.444	-0.365	-0.486	-0.443	-0.473	-0.333	-0.476	-0.492	-0.384	-0.551	-0.615	-0.471	-0.574	-0.749*	-0.515
		(0.459)	(0.389)	(0.382)	(0.409)	(0.429)	(0.414)	(0.389)	(0.372)	(0.362)	(0.470)	(0.468)	(0.444)	(0.408)	(0.423)	(0.391)
ln Distance to large city		0.0264	0.261	0.407**	0.243	0.287	0.207	0.398**	0.291	0.275	0.167	0.203	0.199	0.390**	0.419**	0.414**
		(0.218)	(0.181)	(0.191)	(0.220)	(0.223)	(0.200)	(0.188)	(0.191)	(0.184)	(0.229)	(0.233)	(0.214)	(0.197)	(0.196)	(0.194)
ln Population density			0.483**	0.462**	0.470**	0.453**	0.337*	0.457**	0.361**	0.349**	0.454**	0.472**	0.442**	0.411**	0.403**	0.393**
			(0.197)	(0.197)	(0.193)	(0.198)	(0.193)	(0.202)	(0.183)	(0.176)	(0.213)	(0.213)	(0.202)	(0.197)	(0.204)	(0.187)
Mortality rate			0.886	0.940	-41.74	-41.83	-42.21	0.557	0.812	1.068	-55.96	-54.02	-54.23	0.406	0.199	0.330
			(1.115)	(0.969)	(29.90)	(32.28)	(31.31)	(0.937)	(1.330)	(1.295)	(36.19)	(35.72)	(33.58)	(1.405)	(1.492)	(1.376)
Fertility rate			-11.34	0.320	11.71	11.72	12.32	-7.340	-4.556	-0.987	10.38	10.25	9.425	-8.127	-9.364	-3.681
			(16.24)	(18.96)	(20.40)	(25.22)	(24.50)	(18.49)	(19.84)	(19.36)	(27.70)	(27.61)	(26.15)	(20.87)	(22.39)	(20.74)
ln Average household size			-0.577***	-0.564***	-0.543*	-0.572	-0.725*	-0.653***	-0.667***	-0.642***	-0.287	-0.257	-0.500	-0.696***	-0.751***	-0.725***
			(0.197)	(0.188)	(0.319)	(0.385)	(0.373)	(0.198)	(0.143)	(0.139)	(0.439)	(0.426)	(0.418)	(0.159)	(0.163)	(0.150)
Protestant population share				0.152	0.152	0.150	0.213	-0.126	0.0696	-0.326	0.239	0.172	0.176	-0.189	-0.129	-0.0783
				(0.417)	(0.376)	(0.417)	(0.406)	(0.431)	(0.433)	(0.419)	(0.461)	(0.465)	(0.435)	(0.456)	(0.457)	(0.450)
ln Distance to capital				1.096	1.279	1.492	0.832	1.090	2.027**	5.493***	-0.311	-0.299	-0.548	0.423	-0.358	-0.392
				(0.782)	(0.921)	(1.005)	(0.962)	(0.787)	(0.894)	(1.350)	(1.370)	(1.221)	(1.150)	(1.243)	(1.025)	(1.047)
International border				-0.344	-0.193	-0.151	-0.0363	-0.428	-0.706*	-0.540	-0.517	-0.324	-0.282	-0.589	-0.647	-0.444
				(0.539)	(0.529)	(0.437)	(0.417)	(0.548)	(0.406)	(0.387)	(0.499)	(0.482)	(0.469)	(0.460)	(0.455)	(0.431)
NUTS2 (province) level				-0.443	-0.653	-0.636	-0.523	-0.619	-0.352	-0.457	-0.830*	-0.813*	-0.792*	-0.651	-0.706	-0.672
				(0.417)	(0.473)	(0.430)	(0.430)	(0.433)	(0.393)	(0.387)	(0.493)	(0.492)	(0.459)	(0.418)	(0.438)	(0.411)
NUTS3 (COROP) level				0.0766	0.0611	0.0720	0.0143	0.0398	0.0155	-0.0131	-0.0396	-0.0369	-0.0261	-0.00333	-0.0447	-0.0189
				(0.0913)	(0.0843)	(0.102)	(0.102)	(0.0939)	(0.0952)	(0.0962)	(0.126)	(0.121)	(0.111)	(0.115)	(0.109)	(0.104)
Soil type (loam)					0.721	0.727	0.428	0.782	0.872*	1.027**	0.342	0.542	0.202	0.625	0.645	0.274
					(0.585)	(0.576)	(0.574)	(0.581)	(0.517)	(0.505)	(0.672)	(0.663)	(0.631)	(0.574)	(0.573)	(0.567)
Soil type (sand)					0.827	0.887*	0.510	0.623	0.636	0.664	0.215	0.422	0.148	0.375	0.316	0.0728
					(0.560)	(0.502)	(0.483)	(0.520)	(0.433)	(0.421)	(0.626)	(0.575)	(0.542)	(0.545)	(0.497)	(0.481)
Maritime border					-0.859**	-0.783	-0.396	-0.675*	-0.296	-0.693	-1.252**	-1.235**	-0.855	-0.874	-1.080**	-0.564
					(0.395)	(0.535)	(0.515)	(0.403)	(0.477)	(0.445)	(0.598)	(0.584)	(0.591)	(0.537)	(0.509)	(0.524)
Access to a river					-0.293	-0.306	-0.567*	-0.506	-0.509*	-0.515*	-0.0154	0.0589	-0.279	-0.407	-0.260	-0.588*
					(0.397)	(0.322)	(0.322)	(0.361)	(0.296)	(0.288)	(0.381)	(0.364)	(0.375)	(0.333)	(0.337)	(0.332)
Constant	0.0415	-0.795	1.133	-9.722	-11.43	-14.07	-7.710	-8.251	-18.34	-58.05***	6.219	6.032	8.444	0.411	9.479	8.771
	(0.0906)	(1.318)	(1.899)	(10.45)	(11.44)	(13.13)	(12.66)	(10.16)	(11.36)	(16.28)	(17.08)	(15.72)	(14.65)	(15.61)	(13.26)	(13.16)

R-squared	0.228	0.278	0.371	0.427	0.367			0.445								
Squared correlation						0.365	0.404		0.416	0.499						
Uncentered R-squared											0.5751			0.6738		
Lambda/Rho coefficient						-.0011259	.0377057		.0008151	-.0301476		.3304426	1.274676		-.9450986	1.461594
p-value						0.627	0.001		0.074	0.000		0.899	0.178		0.656	0.074
Wald test (lambda/rho=0)						0.236	10.676		3.201	18.409						
p-value						0.627	0.001		0.074	0.000						
Likelihood r. test (lambda/rho=0)						0.208	10.353		7.442	17.478						
p-value						0.648	0.001		0.006	0.000						
Lagrange m. test (lambda/rho=0)						1.428	7.855		1.531	5.573						
p-value						0.232	0.005		0.216	0.018						
Underidentification test (Anderson LM statistic)											18.663			12.721		
p-value											0.000			0.0000		
Weak identification test (CDW F statistic)											18.375			12.051		
Overidentification test (Sargan statistic)											15.922			18.369		
p-value											0.0000			0.0025		
Observations	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177

Notes: All variables are in logarithm, using ln(x+1), except for percentage values and dummy variables. Distances are expressed in kilometers. Columns (5) - (16) add dummies for the three soil types in the region (i.e. *Sand*, *Loam*, and *Peat*), excluding *Peat* as a dummy to avoid collinearity. T-statistics are reported in brackets; standard errors are robust to control for heteroscedasticity. The asterisks denote significance levels, respectively for *** p<0.01, ** p<0.05, and * p<0.1. Columns (6), (7), (9) and (10) were calculated with the STATA commands for spatial regressions of Pisati (2001) and columns (12), (13), (15), and (16) were calculated with the STATA commands for spatial regressions of Drukker, Prucha, and Raciborski (2013), both constructing a binary spatial matrix with the distance band set at the smallest maximum distance between spatial units.

Table 14. Effect of proto-industry (1850) on employment in modern industry (1890) in Flanders

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	IV	IV	IV	IV	IV	IV
						(Error)	(Lag)		(Error)	(Lag)		(Error)	(Lag)		(Error)	(Lag)
	ln Employment in modern industry (1890)															
ln Employment in proto-industry (1850)	-0.00927	0.00230	-0.0251	-0.0620*	-0.0459	-0.0728**	-0.0509	-0.0589	-0.0812**	-0.0771**	0.0528	0.0438	0.0362	0.0146	0.0462	0.00327
	(0.0373)	(0.0284)	(0.0317)	(0.0370)	(0.0453)	(0.0350)	(0.0347)	(0.0443)	(0.0353)	(0.0351)	(0.0755)	(0.0665)	(0.0558)	(0.0802)	(0.0688)	(0.0555)
ln Average wage rate		0.462*	0.513*	0.315	0.0944	0.158	0.106	0.216	0.215	0.176	0.0990	0.0985	0.127	0.224	0.226	0.150
		(0.267)	(0.265)	(0.284)	(0.207)	(0.118)	(0.118)	(0.292)	(0.150)	(0.173)	(0.117)	(0.124)	(0.118)	(0.173)	(0.177)	(0.175)
Literacy rate		-0.00389	0.00427	0.00944	-0.669	-0.542	-0.632	0.00817	0.00756	0.0101	-0.268	-0.305	-0.224	0.0101	0.0110	0.0123
		(0.00613)	(0.00665)	(0.00662)	(0.438)	(0.507)	(0.510)	(0.00659)	(0.00747)	(0.00787)	(0.580)	(0.556)	(0.540)	(0.00807)	(0.00806)	(0.00795)
Presence of a railway station		0.422***	0.287**	0.260**	0.0993	0.106	0.0957	0.232*	0.247**	0.222*	0.0992	0.0994	0.0164	0.213*	0.205*	0.202*
		(0.126)	(0.118)	(0.121)	(0.229)	(0.174)	(0.175)	(0.119)	(0.120)	(0.121)	(0.176)	(0.177)	(0.178)	(0.123)	(0.123)	(0.122)
Presence of a bank		0.641**	0.398	0.369	0.651**	0.691***	0.664***	0.378	0.550***	0.389*	0.707***	0.702***	0.709***	0.443**	0.470**	0.451**
		(0.289)	(0.317)	(0.323)	(0.318)	(0.197)	(0.199)	(0.323)	(0.211)	(0.204)	(0.203)	(0.201)	(0.200)	(0.215)	(0.211)	(0.209)
Large city		0.937*	0.778	0.789	0.679	0.622**	0.675**	0.714	0.750***	0.694**	0.781**	0.772**	0.917***	0.762***	0.783***	0.880***
		(0.553)	(0.549)	(0.538)	(0.526)	(0.293)	(0.295)	(0.535)	(0.276)	(0.284)	(0.305)	(0.304)	(0.303)	(0.289)	(0.292)	(0.289)
ln Distance to large city		-0.285***	-0.238***	-0.234***	-0.302***	-0.298***	-0.301***	-0.242***	-0.225***	-0.240***	-0.311***	-0.311***	-0.288***	-0.255***	-0.261***	-0.239***
		(0.0821)	(0.0841)	(0.0807)	(0.0721)	(0.0356)	(0.0359)	(0.0807)	(0.0369)	(0.0385)	(0.0367)	(0.0372)	(0.0371)	(0.0408)	(0.0407)	(0.0401)
ln Population density			0.304***	0.364***	0.327**	0.322***	0.324***	0.383***	0.338***	0.405***	0.258**	0.265***	0.230**	0.325***	0.299***	0.323
			(0.103)	(0.105)	(0.144)	(0.0911)	(0.0920)	(0.106)	(0.0890)	(0.0914)	(0.104)	(0.0997)	(0.0976)	(0.108)	(0.106)	(0.0973)
Mortality rate			0.0216	0.0253	5.665	8.743	6.428	0.0112	0.00815	0.0138	5.791	5.797	5.935	0.00642	0.00416	0.0137
			(0.0362)	(0.0378)	(6.405)	(8.976)	(9.068)	(0.0364)	(0.0526)	(0.0532)	(9.059)	(9.233)	(9.041)	(0.0538)	(0.0537)	(0.0537)
Fertility rate			1.533	2.132	12.51*	14.97*	13.24	1.373	-0.444	1.074	15.13*	14.87*	18.90**	1.369	1.384	1.127
			(1.686)	(1.556)	(6.602)	(8.801)	(8.867)	(1.596)	(2.041)	(2.166)	(9.041)	(9.022)	(8.993)	(2.174)	(2.200)	(2.176)
ln Average household size			0.00837	0.0104	-0.170	-0.230**	-0.181*	0.00926	0.0195	0.00916	-0.201*	-0.198*	-0.200*	0.00681	0.00579	0.0102
			(0.0390)	(0.0372)	(0.111)	(0.109)	(0.108)	(0.0358)	(0.0186)	(0.0187)	(0.110)	(0.114)	(0.109)	(0.0190)	(0.0189)	(0.0190)
French-speaking population share				0.238	-0.156	-0.102	-0.168	0.183	0.0832	0.136	-0.123	-0.126	-0.141	0.283	0.328	0.221
				(0.481)	(0.375)	(0.415)	(0.417)	(0.480)	(0.305)	(0.302)	(0.420)	(0.433)	(0.419)	(0.319)	(0.316)	(0.310)
ln Distance to capital				-0.0268	-0.108	-0.402*	-0.0999	0.0363	-0.0698	-0.0719	-0.128	-0.125	0.0306	0.0183	0.00401	0.130
				(0.277)	(0.280)	(0.241)	(0.232)	(0.270)	(0.116)	(0.247)	(0.234)	(0.308)	(0.239)	(0.241)	(0.333)	(0.245)
International border				-0.283	-0.111	0.109	-0.0839	-0.282	-0.0843	-0.220	-0.0886	-0.0907	0.0350	-0.216	-0.188	-0.113
				(0.230)	(0.225)	(0.228)	(0.219)	(0.225)	(0.212)	(0.213)	(0.217)	(0.234)	(0.220)	(0.221)	(0.226)	(0.217)
NUTS2 (province) level				-0.135	-0.0750	0.0513	-0.0652	-0.192	-0.294	-0.106	-0.194	-0.183	-0.234	-0.287	-0.327	-0.334
				(0.257)	(0.260)	(0.260)	(0.257)	(0.253)	(0.250)	(0.262)	(0.271)	(0.309)	(0.263)	(0.275)	(0.321)	(0.265)
NUTS3 (arrondissement) level				-0.0256	-0.0347	-0.00124	-0.0253	-0.0333	-0.0209	-0.000797	-0.0242	-0.0252	0.0115	-0.0187	-0.0119	0.0145
				(0.0314)	(0.0318)	(0.0320)	(0.0338)	(0.0315)	(0.0346)	(0.0351)	(0.0314)	(0.0381)	(0.0327)	(0.0331)	(0.0379)	(0.0328)
Soil type (loam)					0.142	0.0436	0.125	0.147	0.144	0.136	-0.124	-0.100	-0.194	-0.0580	-0.146	-0.163
					(0.244)	(0.238)	(0.239)	(0.175)	(0.188)	(0.212)	(0.301)	(0.292)	(0.267)	(0.294)	(0.277)	(0.245)
Soil type (sand)					0.00609	-0.0610	-0.0157	-0.122	-0.295	-0.161	-0.282	-0.255	-0.357	-0.325	-0.414	-0.451*
					(0.238)	(0.240)	(0.243)	(0.201)	(0.235)	(0.232)	(0.312)	(0.298)	(0.274)	(0.307)	(0.286)	(0.262)
Maritime border					-0.339	-0.293	-0.325	-0.500*	0.0663	-0.504	-0.172	-0.187	-0.148	-0.405	-0.363	-0.354
					(0.272)	(0.330)	(0.332)	(0.286)	(0.366)	(0.348)	(0.353)	(0.353)	(0.342)	(0.363)	(0.368)	(0.355)
Access to a river					0.374***	0.359***	0.376***	0.320***	0.278**	0.338***	0.401***	0.399***	0.340***	0.344***	0.352***	0.310**
					(0.124)	(0.117)	(0.118)	(0.117)	(0.120)	(0.119)	(0.120)	(0.123)	(0.121)	(0.122)	(0.125)	(0.121)
Constant	0.539***	0.675	-3.243	-2.488	3.015	5.049**	2.686	-2.439	-2.794***	-2.019	3.379	3.333	0.423	-1.985	-1.714	-3.831
	(0.202)	(1.615)	(2.092)	(3.841)	(2.885)	(2.417)	(2.505)	(3.763)	(0.707)	(3.329)	(2.482)	(3.273)	(2.644)	(3.374)	(4.191)	(3.432)

R-squared	0.000	0.389	0.404	0.421	0.422			0.430								
Squared correlation						0.405	0.422		0.416	0.433						
Uncentered R-squared											0.4626			0.4736		
Lambda/Rho coefficient						.0006817	.0014316		-.0382736	.0029904		1.383657	2.599262		1.586152	2.188904
p-value						0.022	0.531		0.000	0.086		0.309	0.002		0.243	0.007
Wald test (lambda/rho=0)						5.217	0.392		18.056	2.945						
p-value						0.022	0.531		0.000	0.086						
Likelihood r. test (lambda/rho=0)						7.185	0.392		36.370	2.937						
p-value						0.007	0.531		0.000	0.087						
Lagrange m. test (lambda/rho=0)						0.729	0.220		0.379	1.628						
p-value						0.393	0.639		0.538	0.202						
Underidentification test (Anderson LM statistic)											111.125			96.465		
p-value											0.0000			0.0000		
Weak identification test (CDW F statistic)											134.156			112.659		
Overidentification test (Sargan statistic)											16.381			8.965		
p-value											0.000			0.000		
Observations	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641

Notes: All variables are in logarithm, using ln(x+1), except for percentage values and dummy variables. Distances are expressed in kilometers. Columns (5) - (16) add dummies for the three soil types in the region (i.e. *Sand*, *Loam*, and *Polder*), excluding *Polder* as a dummy to avoid collinearity. T-statistics are reported in brackets; standard errors are robust to control for heteroscedasticity. The asterisks denote significance levels, respectively for *** p<0.01, ** p<0.05, and * p<0.1. Columns (6), (7), (9) and (10) were calculated with the STATA commands for spatial regressions of Pisati (2001) and columns (12), (13), (15), and (16) were calculated with the STATA commands for spatial regressions of Drukker, Prucha, and Raciborski (2013), both constructing a binary spatial matrix with the distance band set at the smallest maximum distance between spatial units.

Table 15. Effect of proto-industry (1850) on steam engines installation (1890) in the Eastern Netherlands

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	IV	IV	IV	IV	IV	IV
						(Error)	(Lag)		(Error)	(Lag)		(Error)	(Lag)		(Error)	(Lag)
	ln Employment in modern industry (1890)															
ln Employment in proto-industry (1850)	0.442***	0.353***	0.385***	0.266***	0.237***	0.234***	0.0988	0.237***	0.163***	0.177***	0.556***	0.818***	0.608***	0.491**	0.854***	0.467***
	(0.0743)	(0.0744)	(0.0708)	(0.0726)	(0.0798)	(0.0667)	(0.0670)	(0.0760)	(0.0622)	(0.0620)	(0.214)	(0.135)	(0.138)	(0.240)	(0.137)	(0.117)
ln Average wage rate		-0.293	-0.267	0.176	-0.0956	-0.0849	0.0625	0.0693	0.355	0.176	-0.129	-0.171	-0.0991	0.289	0.552	0.311
		(0.329)	(0.351)	(0.321)	(0.128)	(0.162)	(0.152)	(0.354)	(0.302)	(0.298)	(0.173)	(0.188)	(0.176)	(0.380)	(0.396)	(0.324)
Literacy rate		-0.212	-1.354	-2.143*	-0.00878	-0.00830	0.0103	-2.115*	-1.300	-1.711	-0.00586	-0.00183	-0.000360	-1.806	-1.177	-1.551
		(1.337)	(1.338)	(1.244)	(0.0240)	(0.0207)	(0.0196)	(1.235)	(1.255)	(1.252)	(0.0222)	(0.0249)	(0.0225)	(1.392)	(1.640)	(1.328)
Presence of a railway station		0.961***	0.835***	0.633***	1.388**	1.334	0.958	0.523**	0.610***	0.647***	1.866*	2.374**	1.925**	0.444*	0.407	0.348
		(0.255)	(0.256)	(0.228)	(0.610)	(0.883)	(0.819)	(0.220)	(0.228)	(0.230)	(0.984)	(1.055)	(0.965)	(0.259)	(0.297)	(0.244)
Presence of a bank		0.0444	-0.117	0.0291	0.828	0.878*	0.812*	-0.0645	0.0513	0.0239	0.858	1.013*	0.820	-0.216	-0.421	-0.168
		(0.380)	(0.356)	(0.323)	(0.666)	(0.520)	(0.475)	(0.339)	(0.281)	(0.283)	(0.547)	(0.613)	(0.554)	(0.337)	(0.378)	(0.306)
Large city		0.398	-0.334	-0.455	-0.526	-0.554	-0.386	-0.549	-0.563*	-0.472	-0.607	-0.795*	-0.571	-0.670*	-0.976**	-0.585
		(0.388)	(0.341)	(0.365)	(0.415)	(0.395)	(0.365)	(0.384)	(0.331)	(0.334)	(0.422)	(0.474)	(0.427)	(0.381)	(0.437)	(0.359)
ln Distance to large city		-0.130	0.112	0.259	0.0681	0.114	0.0654	0.241	0.0905	0.157	0.0110	0.0656	0.0146	0.231	0.321*	0.270
		(0.223)	(0.211)	(0.202)	(0.230)	(0.204)	(0.176)	(0.203)	(0.171)	(0.169)	(0.205)	(0.210)	(0.206)	(0.184)	(0.190)	(0.179)
ln Population density			0.412**	0.477***	0.530***	0.508***	0.360**	0.530***	0.399**	0.439***	0.517***	0.550**	0.493**	0.472**	0.464**	0.439**
			(0.180)	(0.179)	(0.195)	(0.183)	(0.169)	(0.183)	(0.163)	(0.163)	(0.191)	(0.216)	(0.194)	(0.184)	(0.211)	(0.172)
Mortality rate			0.0997	0.339	-12.86	-12.92	-16.45	0.193	0.523	0.615	-23.58	-23.45	-30.10	0.00626	-0.105	-0.210
			(1.224)	(1.116)	(26.65)	(29.75)	(27.60)	(1.150)	(1.185)	(1.195)	(32.44)	(35.80)	(32.28)	(1.311)	(1.538)	(1.264)
Fertility rate			-26.96*	-10.58	8.433	8.234	10.69	-16.34	-13.10	-12.01	7.429	5.492	5.673	-17.31	-18.18	-11.53
			(15.91)	(19.15)	(20.43)	(23.28)	(21.59)	(18.62)	(17.71)	(17.84)	(24.83)	(28.40)	(25.14)	(19.48)	(23.12)	(19.00)
ln Average household size			-0.634***	-0.590***	-0.194	-0.229	-0.426	-0.620***	-0.640***	-0.610***	-0.000663	0.160	-0.110	-0.673***	-0.762***	-0.717***
			(0.169)	(0.170)	(0.331)	(0.356)	(0.328)	(0.186)	(0.128)	(0.129)	(0.393)	(0.424)	(0.400)	(0.149)	(0.167)	(0.138)
Protestant population share				-0.0383	0.193	0.193	0.372	-0.218	0.0358	-0.407	0.259	0.218	0.259	-0.296	-0.185	-0.195
				(0.391)	(0.347)	(0.385)	(0.359)	(0.412)	(0.386)	(0.387)	(0.413)	(0.446)	(0.417)	(0.425)	(0.448)	(0.410)
ln Distance to capital				2.241***	2.215**	2.415**	1.452*	1.956**	2.264**	1.111	1.015	0.0993	-0.413	1.129	-0.160	-0.452
				(0.798)	(0.947)	(0.947)	(0.852)	(0.854)	(0.880)	(0.791)	(1.228)	(1.092)	(1.134)	(1.160)	(1.007)	(0.994)
International border				0.494	0.791	0.841**	1.066***	0.545	0.193	0.399	0.547	0.526	0.715	0.345	0.103	0.631
				(0.533)	(0.514)	(0.403)	(0.369)	(0.565)	(0.363)	(0.358)	(0.447)	(0.474)	(0.461)	(0.429)	(0.466)	(0.404)
NUTS2 (province) level				0.0857	-0.0137	-0.00710	0.134	-0.0911	0.224	0.0369	-0.147	-0.249	-0.225	-0.130	-0.254	-0.200
				(0.425)	(0.488)	(0.404)	(0.378)	(0.451)	(0.359)	(0.357)	(0.442)	(0.479)	(0.441)	(0.390)	(0.445)	(0.377)
NUTS3 (COROP) level				0.158*	0.143	0.152	0.0802	0.112	0.0689	0.0671	0.0674	0.0245	0.0261	0.0584	-0.00282	0.0281
				(0.0874)	(0.0873)	(0.0959)	(0.0901)	(0.0915)	(0.0874)	(0.0888)	(0.113)	(0.113)	(0.107)	(0.108)	(0.108)	(0.0952)
Soil type (loam)					0.455	0.444	0.0709	0.577	0.684	0.828*	0.170	0.161	-0.272	0.382	0.248	-0.195
					(0.539)	(0.537)	(0.505)	(0.530)	(0.461)	(0.468)	(0.602)	(0.626)	(0.610)	(0.536)	(0.580)	(0.523)
Soil type (sand)					1.011**	1.068**	0.586	0.844*	0.864**	0.910**	0.550	0.413	0.0624	0.536	0.278	0.0141
					(0.506)	(0.459)	(0.425)	(0.469)	(0.386)	(0.389)	(0.561)	(0.546)	(0.524)	(0.508)	(0.501)	(0.445)
Maritime border					-0.925**	-0.841*	-0.289	-0.797**	-0.297	-0.856**	-1.222**	-1.455***	-0.991*	-1.044**	-1.420***	-0.644
					(0.380)	(0.492)	(0.453)	(0.361)	(0.425)	(0.411)	(0.536)	(0.549)	(0.559)	(0.502)	(0.510)	(0.475)
Access to a river					0.300	0.280	-0.0483	-0.0190	-0.0251	-0.0220	0.509	0.750**	0.384	0.105	0.339	-0.110
					(0.372)	(0.297)	(0.282)	(0.355)	(0.264)	(0.266)	(0.342)	(0.358)	(0.350)	(0.311)	(0.347)	(0.299)
Constant	0.175*	-0.273	2.872	-23.85**	-25.73**	-28.15**	-18.72*	-20.14*	-31.78***	-63.14***	-12.42	-2.777	3.317	-9.511	5.474	7.433
	(0.0931)	(1.266)	(1.838)	(10.39)	(11.77)	(12.41)	(11.19)	(10.92)	(10.71)	(15.29)	(15.31)	(14.23)	(14.41)	(14.57)	(13.07)	(12.41)

R-squared	0.254	0.331	0.429	0.511	0.447			0.524								
Squared correlation						0.445	0.525		0.475	0.562						
Uncentered R-squared											0.6823			0.7356		
Lambda/Rho coefficient						-.000629	.0485246		.0006385	-.0226047		-1.172615	1.459048		-1.912016	1.988589
p-value						0.544	0.000		0.002	0.000		0.636	0.069		0.450	0.003
Wald test (lambda/rho=0)						0.367	27.933		9.182	15.059						
p-value						0.544	0.000		0.002	0.000						
Likelihood r. test (lambda/rho=0)						0.338	25.858		16.374	14.429						
p-value						0.561	0.000		0.000	0.000						
Lagrange m. test (lambda/rho=0)						7.679	24.652		0.663	6.011						
p-value						0.006)	0.000		0.415	0.014						
Underidentification test (Anderson LM statistic)											18.663			12.721		
p-value											0.0000			0.0004		
Weak identification test (CDW F statistic)											18.375			12.051		
Overidentification test (Sargan statistic)											13.882			14.448		
p-value											0.000			0.000		
Observations	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177

Notes: All variables are in logarithm, using ln(x+1), except for percentage values and dummy variables. Distances are expressed in kilometers. Columns (5) - (16) add dummies for the three soil types in the region (i.e. *Sand*, *Loam*, and *Peat*), excluding *Peat* as a dummy to avoid collinearity. T-statistics are reported in brackets; standard errors are robust to control for heteroscedasticity. The asterisks denote significance levels, respectively for *** p<0.01, ** p<0.05, and * p<0.1. Columns (6), (7), (9) and (10) were calculated with the STATA commands for spatial regressions of Pisati (2001) and columns (12), (13), (15), and (16) were calculated with the STATA commands for spatial regressions of Drukker, Prucha, and Raciborski (2013), both constructing a binary spatial matrix with the distance band set at the smallest maximum distance between spatial units.

Table 16. Effect of proto-industry on steam engines installation in Flanders

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	IV	IV	IV	IV	IV	IV
						(Error)	(Lag)		(Error)	(Lag)		(Error)	(Lag)		(Error)	(Lag)
	ln Employment in modern industry (1890)															
ln Employment in proto-industry (1850)	-0.0280	-0.0206	-0.0396	-0.0826**	-0.0555	-0.081***	-0.0602**	-0.0810**	-0.109***	-0.096***	0.108	0.0562	0.0406	0.0445	0.0259	-0.0136
	(0.0354)	(0.0254)	(0.0287)	(0.0332)	(0.0433)	(0.0303)	(0.0302)	(0.0405)	(0.0301)	(0.0301)	(0.0670)	(0.0618)	(0.0479)	(0.0698)	(0.0671)	(0.0470)
ln Average wage rate		0.394	0.428*	0.264	0.134	0.197*	0.144	0.194	0.231*	0.162	0.142	0.178	0.174*	0.209	0.159	0.125
		(0.255)	(0.253)	(0.267)	(0.185)	(0.103)	(0.102)	(0.275)	(0.129)	(0.149)	(0.104)	(0.108)	(0.101)	(0.151)	(0.152)	(0.149)
Literacy rate		-0.00558	0.00207	0.00763	-0.426	-0.303	-0.391	0.00659	0.00685	0.00821	0.238	0.0753	0.0484	0.00987	0.00889	0.0100
		(0.00553)	(0.00611)	(0.00608)	(0.347)	(0.440)	(0.444)	(0.00599)	(0.00652)	(0.00677)	(0.514)	(0.485)	(0.466)	(0.00703)	(0.00694)	(0.00677)
Presence of a railway station		0.390***	0.294***	0.266**	0.201	0.210	0.200	0.244**	0.258**	0.236**	0.201	0.191	0.116	0.212**	0.220**	0.216**
		(0.106)	(0.103)	(0.103)	(0.216)	(0.151)	(0.152)	(0.102)	(0.103)	(0.104)	(0.156)	(0.155)	(0.153)	(0.107)	(0.105)	(0.104)
Presence of a bank		0.531**	0.389	0.383	0.575**	0.616***	0.588***	0.385	0.543***	0.392**	0.668***	0.613***	0.635***	0.495***	0.455**	0.461***
		(0.248)	(0.265)	(0.266)	(0.271)	(0.171)	(0.173)	(0.268)	(0.178)	(0.175)	(0.180)	(0.174)	(0.173)	(0.187)	(0.181)	(0.178)
Large city		0.700	0.509	0.517	0.623	0.567**	0.619**	0.488	0.453*	0.477*	0.792***	0.775***	0.918***	0.571**	0.581**	0.687***
		(0.477)	(0.466)	(0.446)	(0.460)	(0.255)	(0.256)	(0.441)	(0.237)	(0.244)	(0.270)	(0.264)	(0.262)	(0.252)	(0.253)	(0.248)
ln Distance to large city		-0.314***	-0.265***	-0.259***	-0.325***	-0.321***	-0.324***	-0.264***	-0.253***	-0.262***	-0.340***	-0.336***	-0.304***	-0.287***	-0.287***	-0.258***
		(0.0748)	(0.0767)	(0.0732)	(0.0660)	(0.0309)	(0.0312)	(0.0736)	(0.0318)	(0.0331)	(0.0325)	(0.0331)	(0.0322)	(0.0356)	(0.0356)	(0.0344)
ln Population density			0.272***	0.353***	0.168	0.163**	0.165**	0.350***	0.331***	0.367***	0.0543	0.0655	0.0586	0.251***	0.265***	0.284
			(0.0976)	(0.0983)	(0.128)	(0.0790)	(0.0800)	(0.0995)	(0.0779)	(0.0785)	(0.0921)	(0.0866)	(0.0843)	(0.0940)	(0.0940)	(0.0830)
Mortality rate			0.0249	0.0292	11.64*	14.53*	12.28	0.0241	0.0166	0.0266	11.85	9.677	11.26	0.0159	0.0154	0.0299
			(0.0350)	(0.0370)	(6.053)	(7.789)	(7.868)	(0.0364)	(0.0453)	(0.0458)	(8.031)	(8.057)	(7.800)	(0.0468)	(0.0455)	(0.0459)
Fertility rate			1.589	2.310	5.504	7.906	6.199	1.667	0.407	1.418	9.842	11.07	12.99*	1.660	1.933	1.407
			(1.532)	(1.425)	(5.265)	(7.637)	(7.710)	(1.438)	(1.736)	(1.863)	(8.015)	(7.863)	(7.770)	(1.893)	(1.885)	(1.857)
ln Average household size			-0.034***	-0.031***	-0.139	-0.196**	-0.148	-0.033***	-0.0228	-0.0330**	-0.189*	-0.178*	-0.170*	-0.0371**	-0.0361**	-0.0320**
			(0.00834)	(0.00799)	(0.0994)	(0.0943)	(0.0940)	(0.00809)	(0.0159)	(0.0161)	(0.0975)	(0.0999)	(0.0938)	(0.0165)	(0.0160)	(0.0162)
French-speaking population share				0.0451	0.0163	0.0648	0.00837	-0.0192	-0.142	-0.0549	0.0705	0.0461	0.0231	0.153	0.129	-0.000766
				(0.432)	(0.303)	(0.360)	(0.362)	(0.433)	(0.258)	(0.259)	(0.373)	(0.390)	(0.362)	(0.278)	(0.271)	(0.265)
ln Distance to capital				0.121	-0.0215	-0.303	-0.0201	0.129	-0.0499	0.0572	-0.0545	-0.310	0.0555	0.0982	-0.212	0.162
				(0.244)	(0.259)	(0.210)	(0.201)	(0.235)	(0.107)	(0.210)	(0.207)	(0.406)	(0.203)	(0.210)	(0.360)	(0.206)
International border				-0.410**	-0.275*	-0.0614	-0.253	-0.381**	-0.206	-0.334*	-0.237	-0.218	-0.118	-0.270	-0.253	-0.213
				(0.166)	(0.145)	(0.198)	(0.189)	(0.164)	(0.180)	(0.183)	(0.192)	(0.203)	(0.189)	(0.193)	(0.199)	(0.185)
NUTS2 (province) level				-0.173	-0.138	-0.0173	-0.128	-0.184	-0.249	-0.138	-0.335	-0.237	-0.270	-0.344	-0.295	-0.292
				(0.215)	(0.219)	(0.226)	(0.223)	(0.210)	(0.202)	(0.223)	(0.240)	(0.325)	(0.227)	(0.239)	(0.348)	(0.226)
NUTS3 (arrondissement) level				-0.0342	-0.0386	-0.00599	-0.0295	-0.0398	-0.0180	-0.0123	-0.0211	-0.00767	0.0109	-0.0149	-0.00321	0.00803
				(0.0278)	(0.0284)	(0.0278)	(0.0296)	(0.0280)	(0.0259)	(0.0304)	(0.0278)	(0.0393)	(0.0280)	(0.0288)	(0.0415)	(0.0278)
Soil type (loam)					0.193	0.0958	0.178	0.125	0.110	0.122	-0.249	-0.126	-0.172	-0.225	-0.222	-0.194
					(0.224)	(0.207)	(0.208)	(0.162)	(0.162)	(0.182)	(0.267)	(0.273)	(0.230)	(0.256)	(0.269)	(0.209)
Soil type (sand)					0.125	0.0602	0.105	0.00311	-0.161	-0.0249	-0.352	-0.250	-0.309	-0.344	-0.375	-0.362
					(0.210)	(0.208)	(0.211)	(0.178)	(0.200)	(0.199)	(0.277)	(0.271)	(0.238)	(0.268)	(0.265)	(0.224)
Maritime border					-0.290	-0.245	-0.277	-0.468*	-0.139	-0.468	-0.0136	-0.0798	-0.0713	-0.305	-0.297	-0.300
					(0.241)	(0.286)	(0.289)	(0.266)	(0.298)	(0.300)	(0.313)	(0.315)	(0.295)	(0.316)	(0.325)	(0.303)
Access to a river					0.311***	0.295***	0.312***	0.285***	0.220**	0.301***	0.354***	0.282***	0.269***	0.326***	0.264**	0.274***
					(0.100)	(0.102)	(0.102)	(0.0985)	(0.102)	(0.103)	(0.106)	(0.109)	(0.104)	(0.106)	(0.109)	(0.104)
Constant	0.573***	1.454	-2.005	-3.114	2.804	4.742**	2.568	-2.655	-2.606***	-2.467	3.406	5.930	0.727	-1.879	1.588	-3.352
	(0.196)	(1.553)	(1.990)	(3.373)	(2.620)	(2.106)	(2.158)	(3.287)	(0.598)	(2.858)	(2.200)	(4.376)	(2.213)	(2.938)	(4.257)	(2.887)

R-squared	0.002	0.442	0.458	0.480	0.469			0.487								
Squared correlation						0.450	0.469		0.473	0.490						
Uncentered R-squared											0.4841			0.5125		
Lambda/Rho coefficient						.0007008	.0014636		-.0333344	.0027619		3.09404	3.038526		3.865066	2.3887
p-value						0.012	0.502		0.000	0.098		0.001	0.000		0.009	0.001
Wald test (lambda/rho=0)						6.247	0.450		27.191	2.740						
p-value						0.012	0.502		0.000	0.098						
Likelihood r. test (lambda/rho=0)						9.014	0.450		39.152	2.733						
p-value						0.003	0.502		0.000	0.098						
Lagrange m. test (lambda/rho=0)						0.671	0.273		0.671	1.601						
p-value						0.413	0.601		0.413	0.206						
Underidentification test (Anderson LM statistic)											111.125			96.465		
p-value											0.0000			0.0000		
Weak identification test (CDW F statistic)											134.156			112.659		
Overidentification test (Sargan statistic)											6.663			8.963		
p-value											0.000			0.000		
Observations	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641	641

Notes: All variables are in logarithm, using ln(x+1), except for percentage values and dummy variables. Distances are expressed in kilometers. Columns (5) - (16) add dummies for the three soil types in the region (i.e. *Sand*, *Loam*, and *Polder*), excluding *Polder* as a dummy to avoid collinearity. T-statistics are reported in brackets; standard errors are robust to control for heteroscedasticity. The asterisks denote significance levels, respectively for *** p<0.01, ** p<0.05, and * p<0.1. Columns (6), (7), (9) and (10) were calculated with the STATA commands for spatial regressions of Pisati (2001) and columns (12), (13), (15), and (16) were calculated with the STATA commands for spatial regressions of Drukker, Prucha, and Raciborski (2013), both constructing a binary spatial matrix with the distance band set at the smallest maximum distance between spatial units.

The results for the control variables in Tables 13-16 allow us to dig deeper into the reasons behind the insignificant effect of proto-industry on modern industry in Flanders and the significant positive effect in the Eastern Netherlands. For the Eastern Netherlands, we find a positive association between population density and employment in modern industry (see Columns 3-16 of Tables 13 and 15). As such, we complement the historiography that stressed the role that labor shortage played in the Eastern Netherlands (e.g. Mastboom 1994: 52-56; Mastboom 1996: 249-250), thereby pushing entrepreneurs to municipalities where labor was available. In the unconditional OLS estimation (see Columns 2-5 of Table 14 and 16), we also find for the Eastern Netherlands a positive association between the presence of a railway station in the municipality and modern industry, plausibly due to the necessity for importing the necessary inputs and exporting the finished textiles products to the extra-regional consumer markets.

In contrast, in Flanders, we find a strong negative significant association between modern industry and the proximity to a large city (see Columns 2-16 of Tables 14 and 16). Additionally, in the IV estimations (see Columns 11-16 of Tables 14 and 16), we find a positive significant association between the large city dummy variable and modern industry. Consequently, we can hypothesize that modern industrial factories appear more as an urban phenomenon in Flanders compared to the Eastern Netherlands: whereas modern industry in Flanders emerged predominantly in large cities or in the vicinity of a large city, modern industry in the Eastern Netherlands developed in areas with access to a railroad connection and a higher population density.

Based on the historiography, we can suggest two reasons which explain the difference in significant control variables between both regions. First, different access to labor markets. Schepens (1973), Gubin and Scholliers (1996), and Thoen (2001) stressed that Flemish factory owners withdrew most laborers from the larger cities. Additionally, Vandenbroeke (1979) and Ronsijn (2014) argued that most laborers in the countryside preferred combining part-time sources of income, among which domestic spinning and weaving, over taking up a full-time job at the factory. In contrast, in the Eastern Netherlands, entrepreneurs are argued to have faced a labor shortage (Mastboom 1994: 52-56; 1996: 249-250), incentivizing factory owners to deploy steam power and set up factories in the countryside, where a willing labor force could be found, among which the former proto-industrial spinners and weavers. Here, the difference in proto-industrial systems could have played a role: whereas the *Kaufsystem* in Flanders implicated a higher cost for proto-industrial laborers to switch to another profession, as argued by Vandenbroeke (1979), Van Der Wee and D’haeseleer (1996), this was less the case for the Eastern Dutch *Verlagsystem*, where the proto-industrial workers were equipped by the merchant-entrepreneurs with raw materials and production material.

Second, both regions faced different access to domestic and foreign consumer markets. Here, the Eastern Dutch factories had less incentives to locate in cities, or local consumer markets: most textiles products in the Eastern Netherlands were bound to exterior markets, to the Dutch urbanized west or Indonesia, and less to the local population, as it constituted a relative poor and low-populated area in the Netherlands. Yet, in Flanders, where most foreign markets dried up during the first half of the nineteenth century, producers turned more to local consumer markets, in the region or closely located to the region, such as in Antwerp and Brussels. In this perspective, it would be more cost-effective for factories in Flanders to locate close to their main consumer markets, predominantly located in cities. Additionally, the larger size of the Flemish textiles sector (in comparison with the Eastern Dutch textiles sector) could have implied greater agglomeration advantages for textiles factories, incentivizing entrepreneurs in Flanders to cluster together in cities due to economics of scale.

All in all, these results reveal that in Flanders modern industry developed in urban centers, due to the proximity of a large market of labor and consumers, thus breaking with the location of proto-industry and explaining the insignificant effect of proto-industry for Flanders in Tables 14 and 16. In contrast, the positive significant effect for proto-industry in the Eastern Netherlands, as found in Tables 13 and 15, affirm the view that proto-industrialization contributed to the development of a modern industry sector in this region. In the Eastern Netherlands, the countryside was able to develop modern industry, due to the labor shortage that factory owners faced and the connection of rural towns via railroads with the main extra-regional consumer markets.

3.6. Conclusion: a tale of two transitions

In the wake of Mendels (1972), a broad and diverse historiography emerged on the topic of proto-industrialization, in which the theory attracted both praise and criticism during the 1980s and 1990s. Yet, whereas this literature has produced valuable contributions to our understanding of proto-industrialization, there has been no econometric test of the key premise of the proto-industrialization thesis, that is, whether or not proto-industrialization had an effect on modern industrialization. As a means to resolve this gap in the historiography, we tested for the effect of employment in proto-industrial textiles production on employment in modern industrial textiles production and the amount of installed steam power for the two largest textiles producing regions in the Netherlands and Belgium: the Eastern Netherlands and Flanders.

Our results present a positive, significant effect of employment in proto-industry on employment in modern industry and installed steam power for the Eastern Netherlands, but an insignificant effect for Flanders, with both effects remaining robust once controlling for additional explanatory factors, spatial dependence and autocorrelation, and once instrumented with livestock on small-scale agricultural holdings. Our evidence is consistent with the majority of the historiography on both regions: the literature that labeled the Eastern Netherlands as a successful case (e.g. Mastboom 1996; Hendrickx 1997; Trompetter 1997), i.e. in which proto-industrialization contributed to the development of a modern industry sector, and the literature that argued how Flanders was an unsuccessful case (e.g. Schepens 1973; Gubin and Scholliers 1996; Thoen 2001). More importantly, our results offer a more nuanced view on the effect of proto-industrialization as similarly argued by Coleman (1983) and Hudson (1990), confirming the view that proto-industrialization paved the way towards modern industrialization for some regions, such as the Eastern Netherlands, but not for all former proto-industrial regions, such as our evidence on Flanders reveals.

Additionally, our results suggest why particular proto-industrial regions were more conducive for transitioning into modern industry as others, as the case of the Eastern Netherlands and Flanders stress the importance of proximity to labor and consumer markets. Our results highlight that modern industry in the Eastern Netherlands predominantly arose in municipalities with a railroad connection, which ensured access to their main consumer markets, in the Dutch west or Indonesia. Additionally, factories arose in the Eastern Netherlands in municipalities with high population density though not exclusively urban areas, as many factory owners in the region are documented to have faced shortages of labor (Mastboom 1994: 52-56; 1996: 249-250). In Flanders, factories predominantly arose in cities, where most of their consumers and laborers could be found, as the majority of factories in Flanders are documented to have drawn on the urban proletariat rather than proto-industrial workers for labor (e.g. Thoen 2001; Ronsijn 2014; Ronsijn forthcoming). Here, the type of proto-industrial organization could have played an additional part. In the Eastern Netherlands, proto-industrial producers were smaller in numbers and more dependent on merchant-entrepreneurs in a putting out system or *Verlagsystem*. Yet, in Flanders, proto-industry relied more upon independent *Kaufsystem*-oriented producers, who are argued to have clung longer onto artisanal production methods (Vandenbroeke 1979; Haagen 1983; Van Der Wee and D'haeseleer 1996). As a consequence, the dependence in Flanders on the widespread proto-industrial activities made the region less resistant to economic shocks: Flemish rural spinners and weavers were less prepared when automation in spinning and weaving unfolded during the 1850s-1860s.

As such, our study provides evidence to reconsider the views of Mendels (1972; 1981; 1982), who put Flanders forward as his example of proto-industrialization. Initially, Mendels (1972: 246) argued that Flanders "could […] be ranked on a continuum of relative failure in achieving the transition". Yet, the position of Mendels (1981; 1982) seems to have shifted on this topic, as Mendels (1982: 88-89) later claimed that Flanders "cannot be placed under the heading of de-industrialization", as the "significance of the industrial revolution in Ghent and Kortrijk" and the French Lille-Roubaix-Tourcoing industry cluster drew laborers from the former Flemish proto-industrial areas.[47] Yet, our results refute both viewpoints. Rather, as illustrated by the work of Ronsijn (2015; forthcoming), we argue that the failed transition from proto-industry to modern industry cause a mass bankruptcy among the plentiful proto-industrial workers during the 1840s. Due to the massive size of the proto-industrial textiles production in Flanders, the region met its own boundaries as the local demand for labor could not absorb all former proto-industrial labor. As a result, many Flemish spinners and weavers returned to agriculture, often combined with additional sources of income.

As a consequence, the classical view of Mendels (1972; 1981; 1982) about proto-industrialization as a process of withdrawal of proto-industrial laborers from the countryside to modern industrial, urbanized centers needs to be reconsidered. Instead, our evidence indicates two alternative patterns in which proto-industrial clusters influenced the location of modern industry. For Flanders, we find that the proto-industrial workers in the countryside had no interest in taking up a modern industrial job in the city, forcing Flemish factory owners in the cities to attract laborers from the urban proletariat. In the Eastern Netherlands, factory owners set up their factory in the countryside due to labor shortages, for which they turned to the former proto-industry laborers on the countryside. Although our results provide considerable insight

[47] Furthermore, Mendels (1982) argued that modern industrial activities in Flanders moved to a concentration point outside the original proto-industrial region, with the exception of the city of Ghent, whereas the core area of the linen industry de-industrialized.

into the circumstances under which proto-industrialization could have transitioned into modern industrialization, there are limitations to our approach. A valuable next step might be to unravel under what micro-economic conditions the transition from proto-industrialization to modern industrialization would have been more successful, by turning to evidence on micro-economic actors such as companies, entrepreneurs, or laborers.

Chapter 4. The transition during the first and second Industrial Revolution

(together with Péter Földvàri and Bas van Leeuwen)[48]

4.1. Introduction: the causes of the Industrial Revolution

With its strong increase in per capita income, the 'industrial revolution' has obviously attracted a large amount of scholarly attention. Various authors have suggested causes of this 'revolution', varying from the availability of coal to wage levels, and urbanization (e.g., Clark 2007; De Vries 2008; Van Zanden 2009; Allen 2009; Wrigley 2010; Mokyr 2012). Many of these studies relate to human capital, either directly or indirectly. For example, the European Marriage Pattern (De Moor and Van Zanden 2010) is argued to have empowered women causing a reduction in fertility rates, therewith increasing investments in human capital of children. Yet, the literature has not been able to present a homogenous view on the role of human capital in the process of early industrialization, in which the discrepancies in empirical studies can roughly be subdivided in three categories.

First, the identification of the effect of human capital on industrialization has been complicated by the heterogeneity of proxies for human capital. For example, in the studies which tested for such an effect during the nineteenth century (Becker et al. 2011; Squicciarini and Voigtländer 2015; Franck and Galor 2018), human capital has been proxied by literacy rates (Becker et al. 2011; Squicciarini and Voigtländer 2015; Franck and Galor 2018), primary school attendance rates (Squicciarini and Voigtländer 2015; Becker et al. 2011), secondary school attendance rates (Becker et al. 2011), public spending on education (Franck and Galor 2018), and even subscription rates to the Encyclopédie of Diderot and d'Alembert (Squicciarini and Voigtländer 2015). From this perspective, it is not surprising that a recent branch of

[48] This chapter is largely based upon the following working paper: Philips, R., Földvàri, P. and Van Leeuwen, B. "The effect of human capital on industrialisation in Belgium and the Netherlands during the nineteenth century". Furthermore, we would like to thank the Historical Database of Local and Cadastral Statistics LOKSTAT-POPPKAD (Quetelet Center, Ghent University), specifically Sven Vrielinck, and the Historical Sample of the Netherlands (HSN), specifically Kees Mandemakers, for providing data. Additionally, we want to thank Joel Mokyr, Regina Grafe, Jacob Weisdorf, Herman de Jong, Stefan Nikolic, and Jan Luiten van Zanden for comments, as well as the participants of the economic history seminar at the University of Groningen, the 2018 Posthumus Conference, and the 2018 World Economic History Conference panel.

literature, critical of the use of aggregate data of human capital, stresses how the 'density in the upper-tail of professional knowledge' or the human capital of knowledgeable and wealthy elites was decisive for the Industrial Revolution but the average human capital level of the general population played a less important – or even unimportant – role (e.g., Mokyr 2012; Squicciarini and Voigtländer 2015; Feldman and Van der Beek 2016; Mokyr 2017; Zeev et al. 2017).

Second, the historiography presents a mixed view about the causal effect of human capital on industrialization over time, in which most notably the differences between the first and second Industrial Revolution have been juxtaposed. Based on endogenous growth theories, which attribute modern economic growth to improving levels of human capital and technology, studies have argued in favour of a so-called technology-skill complementarity (see, e.g., Goldin and Katz 1998; Acemoglu 2002). For instance, the research of Goldin and Katz (1998) in USA during 1909-1929 proved empirically that such a complementarity was present during the second phase of industrialization, a finding in line with unified growth models (Galor 2011). Yet, whether such a technology-skill complementarity was present during the first phase of industrialization remains more a topic of debate (see, e.g., Mitch 1999; Crafts 1996; Clark 2005). As Galor and Moav (2006: 90) eloquently summarize: "In the first phase of the Industrial Revolution, human capital had a limited role in the production process […] In the second phase of the Industrial Revolution, education reforms were designed primarily to satisfy the increasing skill requirements in the process of industrialization".

Third, there is an aggregation problem. In accordance to the historiography which stresses the regional nature of the Industrial Revolution (e.g. Pollard 1982: VII; O'Brien 1986: 297), most studies focus on the relation between human capital and industrialization across macro-regions, which often aggregated the number of employees or installed steam engines over the whole industry sector (e.g. Squicciarini and Voigtländer 2015; Franck and Galor 2018). Nonetheless, the found results can differ depending on the existing industry mix in a region, as several studies have stressed the non-negligible differences in demand for human capital over industrial sectors. For instance, Nicholas and Nicholas (1992), who found an association between illiteracy and skill levels in occupations based on a large sample of English men during the 1820s-1840s, found evidence for grave differences in illiteracy rates across occupational groups, in which industry workers in watchmaking and printing were found to be highly literate, whereas coal miners and textile workers were found to be the occupational groups with the highest illiteracy rates. Likewise, Becker et al. (2011) found that human capital had no effect on textiles production, but had a significant effect for the metal and other industries during the first phase of industrialization in Prussia.

Thus, while many theories suggest that industrialization is, at least partly, driven by the accumulation of human capital, the aforementioned problems complicate the empirical identification of the effect of human capital on early industrialization. Here, we study the effect of human capital on industrialization in nineteenth century Belgium and the Netherlands, two countries where the effect of human capital has largely remained untested, for which we deal with the aforementioned problems systematically. Using the population and industry censuses in both countries, we compile a panel dataset on the number of steam engines and human capital across twenty-nine industry sectors and twenty regions over the nineteenth century. We explain the number of installed steam engines in a particular sector and region with the correlation of an industry and region characteristic of human capital, e.g. between the region's endowment of human capital and the industry's demand for skilled workers, in which we measure the region characteristic with four different indicators of human capital.

For the first Industrial Revolution in the Low Countries (1820-1850), we find a negative effect of literacy rates on steam engines, which affirms the studies that argued that the first Industrial Revolution favoured regions with an unskilled and cheap labour force (e.g. Pollard 1978; Humphries and Schneider 2018) and downplayed the effect of human capital for the first Industrial Revolution (e.g., Crafts 1996; Mitch 1999; Clark 2005; Galor and Moav 2006). For the second phase of industrialization (1850-1890), we find a positive significant effect of sold newspapers per capita and secondary school attendance rates on industrialization, in line with the studies that argued for a skill-complementary during the second phase of industrialization (e.g. Goldin and Katz 1998; Acemoglu 2002).

The chapter proceeds as the following. Section 2 presents a short background on the historiography on the Industrial Revolution in the Netherlands and Belgium, Section 3 presents the empirical analysis. Section 4 provides a description of the data used in the analysis, after which we study the effect of human capital on technology during the first and second phase of industrialization in Section 5. Finally, we describe our conclusions in Section 6.

4.2. The Industrial Revolution in Belgium and the Netherlands

Though Belgium and the Netherlands shared many cultural, social, economic, and linguistic similarities in the pre-industrial era, even undergoing a brief period of personal union during the United Kingdom of the Netherlands (1815 - 1839), both countries underwent very different paths of industrial development. Often, studies have used this comparison of an early follower (Belgium) and a lagger (the Netherlands) to discuss the causes of the Industrial Revolution. Generally, the Industrial Revolution in Belgium is placed during the 1800-1850 period. As such, Belgium was the first country to successfully adopt British technology, during the early 1800s, earning the title of the second country in the world to industrialize.[49] The Netherlands is argued to have pursued this path to industrialization relatively late, from the 1840s onwards, as the Netherlands experienced an economic standstill in the first half of the nineteenth century (Van Zanden and Van Riel 2000; Smits et al. 2000). As a result, implementation of new production techniques was fairly limited during the first half of the nineteenth century for the Netherlands compared to its northern neighbour: in the 1850s, the Netherlands had 423 steam engines installed in mining and manufacturing sectors, whereas Belgium had already 1502.[50] Yet, after the 1840s – 1860s, after a series of political and economic reforms, the Netherlands is argued to have embarked on a process of continuous economic growth and industrialization (Van Zanden and Van Riel 2000; Smits et al. 2000).

Numerous studies gathered quantitative evidence on the early Belgian take-off and the Dutch tardiness, though most of these studies in an exclusive Belgian or Dutch perspective (e.g. Brugmans 1956; De Brabander 1983; Pluymers 1992). Following the pioneer work of Mokyr (1974; 1976), studies used the divergent industrial performance of both countries to study both within a comparative perspective. Mokyr (1974; 1976) argued that the high wage levels in the Netherlands proved an obstacle in its industrialization process, whereas Belgium benefitted from a relative low wage rate and abundant coal reserves. Subsequently, Van Houtte (1972), Bos (1979), and Griffiths (1979) provided more thorough evidence on the Netherlands, and pointed next to wage differences, also to price differences, of which high coal prices as a result of high indirect taxes and a lack of railway connections to German or Belgian coal mines are argued to have delayed the country's industrial take-off. Conversely, Riley (1969) argued that the coal reserves in the Belgian south and an efficient transport system to transport coal to other Belgian regions was a major factor in the offset of the Belgian Industrial Revolution.

[49] The first steam engines were introduced in Belgium in the late 1790s - early 1800s, though on a limited scale at first. So, did the English emigrant technician William Cockerill install the first wool spinning machines in Verviers in 1799. Lieven Bauwens successfully smuggled parts of a mule out of England to set up the first mechanized cotton spinning mill in Ghent in 1801.
[50] Total number of steam engines based on data from Belgian census of industry (1846) and Steenaard (1989), augmented with the surveys of steam plants in the Netherlands conducted by the provincial governors in 1851.

Additionally, Vandermotten (1997) pointed to the relevance of the former proto-industrial tradition and the Brussels banking cluster to raise the necessary capital for entrepreneurs in Belgium. In contrast, due to the relative high coal prices and the larger number of wind and water mills in the Netherlands, Lintsen and Steenaard (1991) argued that it was rational for Dutch entrepreneurs to delay the implementation of steam power and continue the use of pre-industrial technologies. Similarly, Davids (1991), ‘t Hart (1993), and Mokyr (2000) argued that the conservative political and entrepreneurial class in the Netherlands prevented the necessary technological innovation.

In addition, a stream of literature studied the spatial distribution of industrial production during the nineteenth century in both countries. For instance, Kint and Van der Voort (1980) argued that the Belgian take-off was mostly confined to a small region within Belgium – the Hainaut and Liège provinces, which was the location of the country’s coal deposits and where soon thereafter the first steam-driven factories arose – whereas the other Belgian and Dutch regions remained fairly similar in the adoption of the technology of the Industrial Revolution. Additionally, De Brabander (1983) and Buyst (2018) argued that the development of new industries during the second Industrial Revolution created a regional shift during the second half of the nineteenth century, with the Brabant and Antwerp regions taking over the leading role of the metallurgy and coal cluster in Hainaut and Liège. Similarly, Ronsse and Rayp (2016) attributed this relocation from south to north to a shift in the locational determinants of industry, with a decreasing importance of coal and an increasing role of market potential. For the Netherlands, Keuning (1955) noted a “rebirth of the peripheral regions” during the first Industrial Revolution, with the first Industrial Revolution benefitting mostly the eastern and southern regions in the Netherlands. Brugmans (1969), Bos (1976), and Atzema and Wever (1994) noted that the second phase of industrialization induced a geographical shift from the eastern and southern regions to the urbanized and most prosperous part of the Netherlands, the western regions, which encompassed the Amsterdam and Rotterdam cities. In line with Keuning (1955), Bos (1976) entitled this shift during the second phase of industrialization as a move from “periphery to centre”.

Thus, although industrialization in both countries during the nineteenth century seems widely discussed, in this list of explanations for the differences in industrialization between Belgium and the Netherlands on the one hand and regional shifts in both countries on the other hand, human capital hardly features. Often, studies pointed to the lower literacy rates in Belgium compared to the higher literacy rates in the Netherlands. As Mokyr (2000: 517) describes: “a large proportion of the population went to school and could read, yet somehow this did not translate itself into an early technological lead […] Instead, Belgium, where illiteracy rates were considerably higher, took the lead on the Continent”. Yet, for the end of the nineteenth century and the turn of the twentieth century, studies have stressed the role of human capital for the industry sector in both countries. For the Netherlands, De Jong (1999) found that the sectors with the highest productivity levels – which De Jong (1999) presented as an indicator of human capital – also experienced highest growth in employment numbers during the Interbellum. For Belgium, Van Meerten (2000) argued that Belgium had specialized in low-wage sectors by the end of the nineteenth century, whereas the beginning of the twentieth century induced a period of rising wages and unforeseen increasing labour productivity, thanks to human capital investment. Therefore, in order to put the above historiography to the test, we study the effect of human capital on industrialization in the Low Countries during the first and second phase of industrialization. In doing so, we set out not only to explain the divergence between the Netherlands and Belgium, but also the regional divergence within both countries.

4.3. Empirical model: testing the effect of human capital on industrialization

In order to isolate the effect of human capital on industrialization, we need a clear conceptual framework. In line with the growth models that test for the effect of education on technological diffusion in industrial followers (e.g. Nelson and Phelps 1966; Benhabib and Spiegel 2005), we follow the model used by Becker et al. (2011) in which the level of education affects industrialization. We perform two separate tests for the effect of human capital on industrialization in the Low Countries, for both the first Industrial Revolution (1820-1850) and the second phase of industrialization (1850-1890). In line with the studies of De Pleijt and Weisdorf (2017), Franck and Galor (2017; 2018), and De Pleijt et al. (2019), we take the number of steam engines as a proxy of industrialization. Our model expresses the number of steam engines or *STEAM* in a particular region $_r$ and industry sector $_i$ as a function of *HC* or the level of human capital, *X* or a set of control variables for each region $_r$, π or a set of control variables for each industry sector $_i$, and an ID random error term $\varepsilon_{i,t}$ with zero mean:

$$STEAM_{i,r\ 1850} = \beta_1 + \beta_2\ HC_{i,r\ 1850} + \beta_3\ X'_{r\ 1850} + \beta_4\ \pi_i + \varepsilon_{i,r} \qquad \textbf{(9)}$$

As an extension to the studies that tested for the relation between human capital and industrialization across regional units (e.g. Becker et al. 2011; Squicciarini and Voigtländer 2015; De Pleijt et al. 2017; De Pleijt et al. 2018; Franck and Galor 2018), we develop a model that explains both the geographical and sectoral distribution of industry. In order to explain industrialization across regions and sectors, we use the interaction effect between an industry characteristic and a region characteristic of human capital to explain industrialization, following the studies which used the Midelfart-Knarvik et. al (2000) model to explain the determinants of industry (e.g. Crafts and Mulatu 2005; Wolf 2007; Klein and Crafts 2012; Ronsse and Rayp 2016). In particular, we explain the number of steam engines per region and per sector by the interaction between the endowment of human capital in a given region $_r$ and the demand for skilled workers in a given industry $_i$:

$$HC_{i,r\ 1850} = \text{Literacy rate}_r \times \text{Skill intensity}_i \qquad \textbf{(10)}$$
$$\text{Primary school enrolment}_r \times \text{Skill intensity}_i$$
$$\text{Secondary school enrolment}_r \times \text{Skill intensity}_i$$
$$\text{Newspaper subscription per capita}_r \times \text{Skill intensity}_i$$

Whereas we take the skill intensity level for the industry characteristic, measured by the average wage per sector, we take four different indicators for the human capital stock in a region: the literacy rate, the primary school enrolment rate, the secondary school enrolment rate, and the newspaper subscription per capita. The intuition is the following: if we assume human capital to be important for industrialization, we expect that the interaction of the availability of human capital in a region and the skill intensity in a sector is significant, meaning that industrialization of high skill-intensive industries locate in regions with a high level of human capital.

Yet, the above empirical model cannot be estimated by ordinary least squares (OLS) without risking an endogeneity bias. More precisely, education and industrialization are very likely to have influenced one another simultaneously. One may hypothesize that increasing living standards due to industrialization increased the demand for human capital and resulted in a higher fiscal capacity which, in theory, allowed the government to provide more and better education. Yet, a positive feedback effect is not the only option: a wide range of studies argued that the introduction of steam during the Industrial Revolution led to a 'deskilling' or skill-intensification of the workforce (De Pleijt and Weisdorf 2017; Franck and Galor 2017; Diebolt et al. 2018; De Pleijt et al. 2019). To remove this possible reverse causality, we employ an instrumental variable (IV) estimator where we take the level of human capital at the beginning of the Industrial Revolution in the Low Countries, in 1820, as an instrument. More precisely, we use the interaction between the regional endowment of human capital and the sectoral demand of skills in the pre-industrial period. Thus, we expand the earlier-developed equation by instrumenting human capital in 1850 with human capital in 1820:

$$HC_{i,r\ 1850} = ø_1 + ø_2\ HC_{i,r\ 1820} + ø_3\ X'_{r\ 1820} + ø_4\ \pi_i + \varepsilon_{i,r} \quad \textbf{(11)}$$

As technology was developed elsewhere, in Britain, we argue that the introduction of steam arrived as an exogenous shock to the Low Countries, with few steam engines installed before 1820. As such, we can assume that by tracing back the human capital level in 1850 to the level in 1820, we can isolate the effect of human capital on steam engines during the first phase of industrialization. In line with Becker et al. (2011), we argue that the level of human capital in 1820 is the result of an accumulation of historical idiosyncrasies, as the variation in human capital in 1820 across the regions in the Low Countries is argued to have been the result of many factors, including differences in religion, wealth, and rule.[51] Yet, the major threat for the validity of our chosen instrument of pre-industrial human capital is that it could be correlated with omitted factors that drive subsequent adaption of steam engines due to common factors of pre-industrial economic development. We control for this issue by including pre-industrial economic indicators per region $_r$ denoted by Y'_r. In particular, we expand the earlier-developed equation by additionally controlling for a set of economic indicators in 1820 per region: demographic factors such as the mortality and fertility rate, measures of agricultural development such as the employment in agriculture and the per hectare productivity in wheat cultivation, and measures of trade activity proxied by the availability of paved roads and the export tonnage of ships. In addition, to rule out that the location of industry in 1850 simply followed the pre-industrial location of industry, we include the employment in industry in 1820 across sectors and regions.

Additionally, we can expect that some regions were more or less conducive to the adoption of steam, depending on the trade-off between replacing old technology and the net gains of introducing steam. The literature has argued that the availability of coal could trigger a higher receptiveness in a region, whereas the availability of alternative energy resources is argued to have imposed a delayed transition to steam. Additionally, old technology such as

[51] For instance, in explaining the difference in average literacy rate between the Netherlands and Belgium, Van Der Woude (1980) pointed to the Dutch protestant tradition of being able to read scripture compared to their catholic Belgian neighbours in the south, whereas De Vries and Van Der Woude (1997) credited this difference to the Dutch period of economic affluence under the Golden Age compared to the economic stagnation in the Southern Netherlands during the early modern period (Van Der Woude 1980).

water and wind mills are argued to have imposed sunk costs (e.g. Crafts and Wolf 2014), thereby imposing a higher replacement cost to implement new technology. For instance, Lintsen and Steenaard (1991) argued that the Dutch northern and eastern regions remained deep into the 19th century dependent on wind and water mills as they faced a comparative disadvantage due to the limited access to coal outputs and the massive amount of wind and water mills installed during the Dutch Golden Age. Therefore, in addition, we control for the different receptiveness to the implementation of steam across regions or Z'_r, by controlling for the number of water and wind mills, the number of employees involved in peat extraction, and the output in coal extraction in region $_r$.

$$STEAM_{i,r\ 1850} = \beta_1 + \beta_2\ HC_{i,r\ 1850} + \beta_3\ X'_{r\ 1850} + \beta_4\ \pi_i + \beta_5\ Y'_{r\ 1820} + \beta_6\ Z'_{r\ 1850} + \varepsilon_{i,r} \quad \textbf{(12)}$$

To repeat our equation to test for the effect of human capital on industrialization during the second phase of industrialization (1850-1890), we explain the number of steam engines or *STEAM* in a particular region $_r$ and industry sector $_i$ in 1890 as a function of *HC* or the level of human capital in 1890, X_r or a set of control variables for each region $_r$ in 1890, π or a set of control variables for each industry sector $_i$, Y_r the set of pre-industrial indicators in 1820, and Z_r or the different receptiveness to the implementation of steam across regions. In addition, to keep the achieved level of industrialization in 1850 constant, we expand the equation with the number of steam engines in 1850:

$$STEAM_{i,r\ 1890} = \beta_1 + \beta_2\ HC_{i,r\ 1890} + \beta_3\ X'_{r\ 1890} + \beta_4\ \pi_i + \beta_5\ Y'_{r\ 1820} + \beta_6\ Z'_{r\ 1890} + \beta_7\ STEAM_{i,r\ 1850} + \varepsilon_{i,r} \quad \textbf{(13)}$$

Lastly, to account for possible remaining variation in institutions across regions, we add robustness checks to control for geography and religion.

4.4. Data and sources: construction of a panel dataset for the nineteenth century

To test the effect of human capital on industrialization, we use the variation over sectors and regions. We differentiate across 20 regions, encompassing the 20 provinces of the United Kingdom of the Netherlands (1815-1839), which became after the demise of the Kingdom the 11 provinces in the Netherlands and the 9 provinces in Belgium, with only minor border changes during the studied period.[52] Additionally, we differentiate across 29 industry sectors, for which we reclassify all industry census sectors in the mining and manufacturing sectors listed in the 4th revision of the International Standard Industrial Classification of All Economic Activities (ISIC). In total, this delivers us a rich dataset of 580 observations, to test the effect of human capital on industrialization in the first and second industrial revolution. For industrialization, we use the number of steam engines over sectors and regions as a proxy. Human capital is constructed by taking the interaction of the human capital level in a region and the skill intensity per sector. For the human capital level in a region, we turn to four different indicators: literacy rate, primary school enrolment, secondary school enrolment, and number of sold newspapers per capita. For the human capital level across sectors, we turn to the average wage rate across industry sectors, which we argue to reflect the skill intensity per sector.

[52] For the distribution over provinces, we had to consider the border changes during this period. In 1820, Belgium and the Netherlands existed under the 'United Kingdom of the Netherlands' (1815–1839), the territory of which differed slightly from the provincial boundaries of the later Belgian and Dutch states, in particular for the provinces of Limburg and Luxembourg. To cater for these differences in provincial boundaries, we use the population ratio in Limburg and Luxembourg in 1820 and 1850 to rescale the variables for 1820 with those for 1850 and 1890 in these provinces.

Table 17. Steam engines in the Dutch and Belgian mining and manufacturing sectors in 1850 – 1890

ISIC division	Description of the ISIC division	1850			1890		
		Bel.	Neth.	Total	Bel.	Neth.	Total
5	Mining of coal and lignite	487	3	490	2,866	0	2,866
6	Extraction of crude petroleum and natural gas	0	0	0	0	0	0
7	Mining of metal ores	46	0	46	25	0	25
8	Other mining and quarrying	34	0	34	676	0	676
9	Mining support service activities	0	0	0	0	0	0
10	Manufacture of food products	206	134	340	3,917	2,241	6,158
11	Manufacture of beverages	109	32	141	1592	402	1,994
12	Manufacture of tobacco products	1	0	1	69	104	173
13	Manufacture of textiles	291	112	403	2143	662	2,805
14	Manufacture of wearing apparel	3	0	3	191	3	194
15	Manufacture of leather and related products	3	0	3	249	45	294
16	Manufacture of wood and of products of wood and cork, except furniture	4	10	14	599	415	1,014
17	Manufacture of paper and paper products	39	16	55	400	179	579
18	Printing and reproduction of recorded media	7	0	7	309	111	420
19	Manufacture of coke and refined petroleum	0	0	0	137	104	241
20	Manufacture of chemicals and chemical	28	20	48	911	235	1,146
21	Manufacture of pharmaceutical products, medicinal chemical and botanical products	1	0	1	5	0	5
22	Manufacture of rubber and plastics products	0	0	0	8	0	8
23	Manufacture of other non-metallic mineral products	23	5	28	3,303	500	3,803
24	Manufacture of basic metals	97	42	139	6,111	123	6,234
25	Manufacture of fabricated metal products, except machinery and equipment	114	28	142	894	155	1049
26	Manufacture of computer, electronic and optical products	0	0	0	321	5	326
27	Manufacture of electrical equipment	0	0	0	17	5	22
28	Manufacture of machinery and equipment n.e.c.	8	12	20	798	113	911
29	Manufacture of motor vehicles, trailers and semi-trailers	0	0	0	94	21	115
30	Manufacture of other transport equipment	1	2	3	109	71	180
31	Manufacture of furniture	0	0	0	107	15	122
32	Other manufacturing	0	5	5	132	14	146
33	Repair and installation of machinery and equipment	0	2	2	0	2	2
	All mining and manufacturing sectors	**1,502**	**423**	**1,925**	**25,983**	**5,525**	**31,508**

Notes: The numbers present the total number of steam engines, by sector, year and country. For this, we aggregated the provincial employment numbers to the national numbers. **Sources**: Belgian census of industry (1846) and Dutch census of population (1849), Belgian census of industry (1896) and Philips (2019) for 1890.

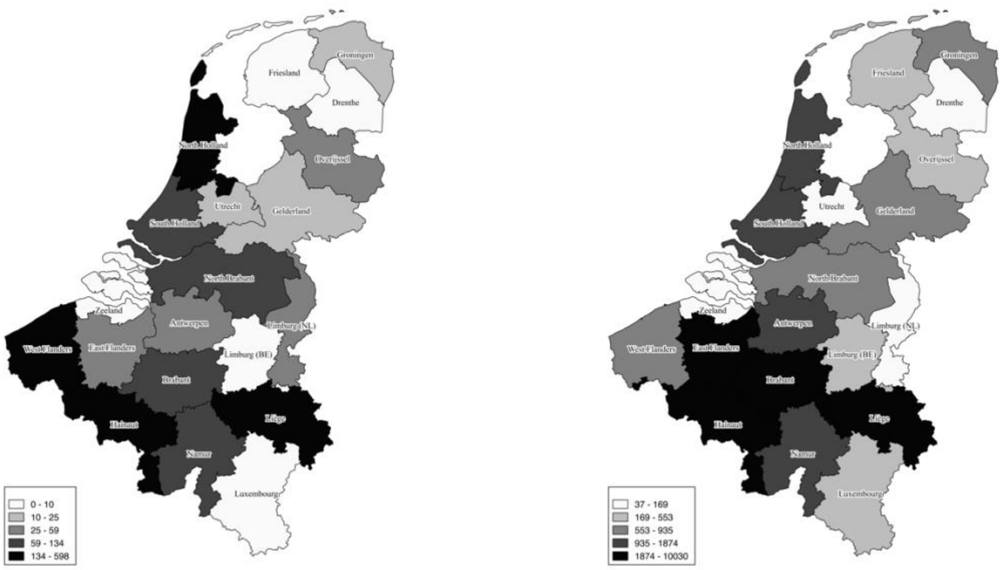
First, being our measure of industrialization, we use the number of steam engines by industrial sector and province. For Belgium in 1850, we use the number of steam engines recorded in the industrial census of 1846. For the Netherlands in 1850, we combine two sources. Primarily, we use the inventory of all steam plants in the first half of the nineteenth century according to the Ministry of Internal Affairs, which was collected by Steenaard (1989). As this source contains only half of all steam engines in the Netherlands according to Lintsen and Steenaard (1991: 122), we augmented this data with the surveys of steam plants in the Netherlands conducted by the provincial governors in 1851, in line with Griffiths (1979) and Lintsen and Steenaard (1991).[53] For Belgium in 1890, we use the steam engines listed in the industrial census of 1896, and for the Netherlands in 1890 we use the steam engines listed in the 1896 municipal reports from Philips (2019). Given the variation in industrial classification schemes between these sources, we subsequently reclassified all sectors listed in these sources to the most-fitting equivalent in the 4th revision of the International Standard Industrial Classification of All Economic Activities (ISIC).

We report the number of steam engines in the Netherlands and Belgium across sectors in Table 17. Here, we find that in 1850, the implementation of steam engines occurred predominantly in two manufacturing sectors: the extraction of coal (ISIC sectors 05-09) and the production of textiles (ISIC sector 13), which together accounted for approximately 50 per cent of the total number of steam engines in the Netherlands and Belgium. In 1890, both sectors accounted for less than 20 per cent. Indeed, the second phase of industrialization induced a period of diversification in the distribution of steam engines across sectors, with notable steam engines installation in the manufacture of basic metals (ISIC sector 24), foodstuffs (ISIC sector 10), and non-metallic mineral products (ISIC sector 23). In addition, Table 17 also reveals differences across both countries. Whereas the Netherlands specialized in foodstuffs and

[53] These surveys are held in the archive of the Dutch Ministry of Manufacturing (*ARA Nationale Nijverheid*). The following codes provide the dates when the lists of steam engines were sent by the provincial governments and their inventory number. For Drenthe: *ARA Nationale Nijverheid*, 07/03/1851, number 66. For Friesland: *ARA Nationale Nijverheid*, 24/03/1851, number 122. For Gelderland: *ARA Nationale Nijverheid*, 31/03/1851, number 95. For Groningen: *ARA Nationale Nijverheid*, 24/03/1851, number 123. For Limburg: *ARA Nationale Nijverheid*, 22/08/1851, number 130. For Noord-Brabant: *ARA Nationale Nijverheid*, 15/04/1851, number 67. For Noord-Holland: *ARA Nationale Nijverheid*, 16/04/1851, number 75. For Overijssel: *ARA Nationale Nijverheid*, 05/04/1851, number 103. For Utrecht: *ARA Nationale Nijverheid*, 08/03/1851, number 102. For Zeeland: *ARA Nationale Nijverheid*, 17/04/1851, number 63. For Zuid-Holland: *ARA Nationale Nijverheid*, 25/03/1851, number 60.

tobacco (ISIC sector 10-12), in Belgium the industry mix was more dominated by production of textiles and apparel (ISIC sector 13-15) and metals (ISIC sector 24-28).

Figure 22. Number of steam engines in 1850 and 1890



(a) number of steam engines in 1850 (b) number of steam engines in 1890

Notes: The figures show the total number of steam engines, aggregated over all industry sectors. **Sources:** for Belgium in 1850, Belgian census of industry (1846). For the Netherlands in 1850, Steenaard (1989), augmented with the surveys of steam plants in the Netherlands conducted by the provincial governors in 1851. For 1890, Belgian census of industry (1896) and the municipal reports collected by Philips (2019).

Figure 22 shows the distribution of steam engines in 1850 and 1890 across provinces. Although Belgium definitely was a forerunner compared to the Netherlands, this regional picture paints a more nuanced picture of the Dutch and Belgian industrialization. Rather than Belgium in totality, it was in a much smaller geographical area – the Hainaut and Liège provinces – in which the Industrial Revolution had taken place by 1850, a point earlier raised by Kint and Van Der Voort (1980). In these regions equipped with coal reserves, the majority of all steam engines in the Low Countries had been installed, thus not only far surpassing all Dutch provinces but also the other provinces in Belgium. The closest forerunners were the Belgian provinces of East Flanders and Brabant, but also the Dutch provinces of North Brabant, Overijssel and North Holland. As such, this regional picture begs to question why the image as if Belgium was an early 'industrialiser' and the Netherlands were not, came to the forefront in the majority of studies on industrialization in the Low Countries after the publication of Mokyr (1976), whereas only few studies on the Netherlands and Belgium have looked at a spatially-disaggregated level for the first half of the nineteenth century (e.g. De Brabander 1983; Atzema and Wever 2004; Ronsse and Rayp 2016; Buyst 2018).

The second group of data consists of indicators of human capital, collected for approximately 1820, 1850, and 1890: primary school attainment, secondary school attainment, literacy rates, and sold newspapers per capita. The percentages of primary and secondary school attendance were calculated as the share of the school population in the population eligible for schooling, obtained from the population censuses. As the switch from primary to secondary education depended on meeting the standard requirements for secondary education and this switch differed from student to student (Mandemakers 1996), it is arbitrary to distinguish the age groups for the eligible population for primary and secondary schools. Following Mandemakers (1996), who argued that the shift from primary to secondary school occurred predominantly at the age between 12 and 14, we use the population aged between 6 and 14 for the population eligible for primary schools and the population aged between 12 and 18 eligible for the secondary schools. To obtain the enrolment in all primary and secondary schools in the Low Countries, excluding vocational schools, we turned to various educational reports by the ministries of education.[54] For 1820, we use the *Verslag over de Scholen van het Koningrijk* of 1827, which reported on the schools in the aforementioned United Kingdom of the Low Countries. For the Netherlands in 1850 and 1890, we use the reports of the ministry of education (*Verslag van den Staat der Hooge, Middelbare en Lagere Scholen in het Koninkrijk der*

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[54] Because of the great variety in schools in the nineteenth century and the various reforms in both countries' educational systems, we faced a difficult choice in our selection of which schools to include in our dataset. As a general rule of thumb, we included all schools with the exception of vocational schools, as these schools did not offer full-time school enrolment and were only marginal in numbers (which is, in part, the reason why the enrolment in these schools were not reported in the used sources). For 1820, we use the *Latijnse scholen* and *Gymnasia* in the former United Kingdom of the Netherlands. For 1850 in the Netherlands, we use the *Latijnse scholen* and *Gymnasia*. For 1850 in Belgium, we use the *Athénes Royaux*, the *établissements communaux subventionnés sur le trésor public* of the first and second level, the *établissements exclusivement communaux* of the first and second level, the *établissements du clergé diriges par les évéques* both *patronnés* and *non-patronnés*, *les congrégations religieuses* both *patronnés* and *non-patronnés* and *les jesuites* and the *établissements diriges par des particuliers, non patronnés*. For 1890 in the Netherlands, we use the *Gymnasia*, the *middelbaar onderwijs voor meisjes*, the *hogere burgerscholen* and the *gymnastieklessen en volledig onderwijs*. For 1890 in Belgium, we use the *Athénes Royaux*, the *collèges communaux*, the *collèges patronnées*, the *garcons ecoles moyennes de l'etat*, the *garcons ecoles moyennes communales*, the *garcons ecoles moyennes patronnées*, the *filles ecoles moyennes de l'etat*, and the *filles ecoles moyennes communales*.

Nederlanden). For Belgium in 1850 and 1890, we turn to the *Annuaire Statistique de la Belgique et la Congo Belge*.

The literacy rates of 1820 for the Low Countries were acquired from Van Der Woude (1980). For the Netherlands in 1850 and 1890, information was derived from the marriage contracts of the Historical Sample of the Netherlands, where the signature of both grooms and brides during 1845 – 1855 and 1895 – 1890 were subdivided by province. From the Belgian population censuses of 1846 and 1900, we were able to obtain similar data on literacy in the Belgian provinces. For evidence on the number of newspapers sold, we turn to a multitude of publications documenting statistics on this topic. Newspaper publishers paid a tax on printed newspapers in the United Kingdom of the Netherlands. Data on the total tax revenues for domestic and foreign newspapers in 1826 (Garnier 1828: 193) enable us to calculate the daily sales of newspapers across the provinces of the Low Countries. As newspapers continued to be taxed in the Netherlands after 1850, we again use the total amount of tax paid in each Dutch province, as collected by Hemels (1969), to calculate the consumption of newspapers in 1850. For Belgium in 1850, Malou (1843) provides the total number of newspaper subscriptions at the provincial level in 1842. For Belgium in 1890, we turn to the 1900 edition of the statistical report of *Chemins de Fer, Postes et Télégraphes*, which reports the number of newspaper subscriptions. For the Dutch statistics in 1890, we use the number of subscriptions to the most sold Dutch newspaper, the *Nieuws van den Dag*, in 1882 as reported by Hemels (1969), which we rescaled to the national total of sold newspapers.[55] Lastly, we calculate the total number of the daily sold newspapers per capita, by dividing the number of the daily sold newspapers by the provincial population total.

[55] The total number of sold newspapers of the *Nieuws van den Dag* in 1882 was 37.622 newspapers, of which 36.777 newspapers were for the domestic market (Hemels 1969). According to Wijfjes (2004: 39) and Huisman (2008: 99), this would have made the *Nieuws* the largest newspaper in the Netherlands at that time, encompassing roughly one fourth of all Dutch newspaper sales. As no national total nor a geographical breakdown for other newspapers could be found for this time period, we are unable to assess how representative the regional distribution of the *Nieuws* is for the distribution of all Dutch newspapers. Nonetheless, given the widespread status of the *Nieuws* as the number one newspaper in the country (Wijfjes 2004), the assumption that the regional market share of the *Nieuws* is representative for the overall Dutch distribution of newspapers seems fair. This seems confirmed when considering the high correlation (0.92) between the provincial distribution of the *Nieuws* in 1882 and the provincial distribution of newspaper subscriptions in 1850, compared to the high correlation (0.98) between the 1820-1850 newspaper distribution in the Netherlands.

Figure 23. Human capital in 1850

(a) Literacy Rates

(b) Primary School Attendance Rates

(c) Secondary School Attendance Rates

(d) Sold Newspapers per Capita

Notes: The figures show the values for 1890 of respectively the literacy rate, the primary school attendance rates as the total number of children attending primary school of the 6-14-year-old population, the secondary school attendance rates as the total number of total number of children attending secondary school of the 12-18-year-old population, and the daily sold newspapers per capita.
Sources: Belgian population census (1846) and Historical Sample of the Netherlands database for the literacy rates, Annuaire Statistique de la Belgique et la Congo Belge (1850) and Ver*slag van den Staat der Hooge, Middelbare en Lagere Scholen in het Koninkrijk der Nederlanden* (1850) for the primary and secondary school attendance rates, and the *Chemins de Fer, Postes et Télégraphes* (1850) for the Belgian sold newspapers per capita rates, Hemels (1969) for the Dutch sold newspapers per capita rates.

Based on Figure 23, we find a different distribution of human capital across the Belgian and Dutch regions in 1850, depending on the indicator of human capital. Overall, Figure 23 confirms the higher literacy rate in the Netherlands: all Dutch regions have noticeably higher values compared to their Belgian counterparts, credible to the Dutch period of economic affluence under the Golden Age (De Vries and Van Der Woude 1997) and the protestant emphasis of being able to read scripture compared to their catholic Belgian neighbours in the south (Van Der Woude 1980). Similarly, primary school enrolment also seems lower in Belgium compared to its northern neighbour, not surprisingly, as schooling would have been the principal channel through which one might learn to read and write. Yet, with regards to the newspaper subscriptions and secondary school attendance rates, both countries appear more at balance. So, we find higher secondary school attendance rates and higher sales of newspapers for the provinces of North Holland, South Holland, Brabant, Antwerp, and Hainaut, the main centres of wealth in the Low Countries at that time (see, e.g., Van Zanden and Van Riel 2014; Buyst 2018).

Table 18. Descriptive statistics for human capital variables

	mean	**std. dev.**	**min.**	**max.**	**Primary school attainment**	**Secondary school attainment**	**Literacy rates**	**Sold newspapers per capita**
Primary school attainment	0.6072	0.1274	0.3422	0.8952	1.0000	-	-	-
Secondary school attainment	0.0176	0.0133	0.0182	0.0546	0.1860 (0.1548)	1.0000	-	-
Literacy rates	0.7009	0.1725	0.3654	0.9889	0.6014*** (0.0000)	0.1899 (0.1460)	1.0000	-
Sold newspapers per capita	0.00271	0.00188	0.00049	0.00423	0.2405 (0.0642)	0.5070*** (0.0000)	0.5043*** (0.0000)	1.0000

Notes: We calculated the mean, standard deviation, minimum, maximum, and Pearson correlation for each group of human capital variables (thus, including the variables over all regions and all benchmark years). Total number of observations per variable is 60. The asterisks denote significance levels, respectively for *** p<0.01, ** p<0.05, and * p<0.1.

The descriptive statistics of these indicators of human capital in Table 18 confirms this heterogeneity over our different measures of human capital. For literacy rates and primary school attendance rates, we find means of 60-70 %, representative for the human capital level of the total population. Instead, for the secondary school attendance rates and the newspaper subscription rates, we find values ranging between 0-5%, thus representative for a small part of the population, most likely the upper branch of society.[56] These findings justify the distinction in the literature between so-called 'upper-tail of professional knowledge' and the 'average' level of human capital possessed by the general population or workforce, as argued in recent literature (e.g., Mokyr 2005; Feldman and Van der Beek 2016; Squicciarini and Voigtländer 2015; Mokyr 2017; Zeev et al. 2017). As such, sold newspapers and secondary school attainment could be considered a proxy for the former and primary school attainment and literacy for the latter. Although both sold newspapers and secondary school attainment do not measure directly the 'upper-tail of professional knowledge' following the definition of Meisenzahl and Mokyr (2012) as the density of the 'highly skilled craftsmen', both indicators do offer a robust indirect proxy of the local demand for knowledge, in this perspective similar to the proxy of Encyclopédie subscriptions as used by Squicciarini and Vogtländer (2015).[57] This assertion seems in line with the moderate correlation between sold newspapers and secondary school attainment on the one hand, and primary school attainment and literacy on the other hand in Table 18.

The third group of data relates to the skill intensity per sector. As no direct proxy measures skill intensity across industry sectors during the nineteenth century, we turn to an indirect indicator: the average wage per sector. Assuming that wages reflect the marginal productivity of a worker, as an extension of the theories on total factor productivity, we can expect a strong positive correlation between the skill intensity per sector and the relative wage rate per sector. Furthermore, based on the Mincer (1974) earnings function which "has been estimated for thousands of data sets for a large number of countries and time periods which clearly makes it one of the most widely used models in empirical economics" (Lemieux 2006:

[56] During the nineteenth century, secondary schooling offered a preparation of the university and as such it was considered an exclusive opportunity for the upper branches of society. For example: Mandemakers (1996) studied the social background of students in the two largest secondary school systems in the Netherlands in 1880. Here, he found that the *Gymnasia* consisted for 70% of children with parents that were well-educated and/or rich, compromising roughly the Dutch 'financial elite' (Mandemakers 1996: 314). Additionally, the *hogere burgerscholen* accounted for 80% children of the middle and higher bourgeoisie class. Similarly, newspapers could be argued to be confined to the upper tranches of society for much of the nineteenth century, considering the opportunity cost of reading newspapers.

[57] Similar to the heterogeneity in the indicators of human capital, the 'density in the upper tail of professional knowledge' has been proxied by various indicators. Feldman and Van der Beek (2016) and Zeev et al. (2017) used apprenticeships, whereas De Pleijt et al. (2018) used the spatial distribution of highly-skilled mechanical working-skills derived from occupations, which are all argued to measure the supply of 'professional knowledge' in a direct fashion. Yet, another stream of literature proxied for the 'density in the upper tail of professional knowledge' with an indirect indicator, which measured the demand for knowledge. For instance, Squicciarini and Voightländer (2015) used subscriber density of the Encyclopédie, in line with the studies that used book subscriptions (e.g. Baten and Van Zanden 2008; Dittmar 2011; Plopeanu et al. 2014) to proxy the demand for 'professional knowledge'.

128), we can assume that earnings are a linear function of the years of education. In this perspective, Broadberry and Fremdling (1990: 412) used the relative wage rate across sectors as indicator of human capital. For 1819, we turn to the average wage level in the largest ISIC subcategory of the industrial census conducted on 31 December 1819 in the former Dutch and Belgian United Kingdom of the Netherlands, as reported by Brugmans (1956). For Belgium, we turned to the reported wages in industry census of 1846 and 1896. As no source was available for mid-nineteenth century Netherlands, we turned to the Belgian 1846 wage structure. For the Netherlands in 1890, we turned to the 1904 edition of the *Statistiek van de loonen der volgens de Ongevallenwet 1901 verzekerde werklieden, in de provincie Gelderland*.

We report the average wage rate for each country and ISIC sector in Table 19. In the early nineteenth century, lowest values are found for the textiles sectors. The low demand for human capital in textile production complements the findings of Becker et al. (2011), who found that the geographical variation in basic education could not explain the variation in employment in textiles, whereas it did for employment in other manufacturing sectors. Additionally, O'Rourke et al. (2013), who argued that innovation in textiles sectors was more oriented towards unskilled than skilled labour. Towards the end of the nineteenth century, coal mining seems to have joined textiles in the lowest percentiles. The lower demand for human capital in coal mining seems comparable to studies on England where, based on anecdotal evidence, it was noted that "colliers were nearly all illiterate" (Morgan and Ó Gráda 2014). Likewise, Nicholas and Nicholas (1992), in their measurement of illiteracy rates among occupational groups, found the highest illiteracy levels among coal miners. Highest values are found for metals and metal products (ISIC sectors 24-28), as well as transport equipment (ISIC divisions 29 and 30), which also seems in line with the findings of Nicholas and Nicholas (1992), which indicate relative high literacy rates among labourers in these sectors.

Table 19. Average wage rate per industry sector in 1820-1890

ISIC division	Description of the ISIC division	1820 (Bel)	1820 (Neth)	1850	1890 (Bel)	1890 (Neth)
5	Mining of coal and lignite	1.763	1.420	3.324	1.704	1.022
6	Extraction of crude petroleum and natural gas	2.045	1.689	3.093	1.432	1.022
7	Mining of metal ores	2.326	1.644	3.291	1.241	1.022
8	Other mining and quarrying	2.004	1.958	2.665	1.592	1.022
9	Mining support service activities	1.617	1.599	2.978	1.560	1.022
10	Manufacture of food products	1.230	1.241	1.840	1.486	1.346
11	Manufacture of beverages	1.511	1.508	2.315	1.408	1.079
12	Manufacture of tobacco products	1.530	1.757	2.680	1.237	1.131
13	Manufacture of textiles	1.000	1.402	1.000	1.370	1.066
14	Manufacture of wearing apparel	1.343	1.042	1.691	1.000	1.317
15	Manufacture of leather and related products	1.287	1.162	1.576	1.248	1.104
16	Manufacture of wood and wood products	1.599	1.643	2.308	1.614	1.272
17	Manufacture of paper and paper products	1.252	1.794	1.738	1.192	1.000
18	Printing and reproduction of recorded media	1.285	1.644	3.399	1.723	1.520
19	Manufacture of coke and refined petroleum	1.319	1.494	3.793	1.651	1.421
20	Manufacture of chemicals and chemical	1.389	1.265	2.471	1.580	1.323
21	Manufacture of pharmaceutical products	2.314	1.657	2.692	1.464	1.378
22	Manufacture of rubber and plastics products	1.974	1.671	2.584	1.348	1.225
23	Manufacture of other non-metallic mineral	1.529	1.848	2.476	1.388	1.073
24	Manufacture of basic metals	1.635	1.000	3.259	1.754	1.348
25	Manufacture of fabricated metal products	1.642	1.407	1.790	1.799	1.510
26	Manufacture of electronic and optical products	1.838	1.620	2.285	1.777	1.699
27	Manufacture of electrical equipment	1.732	1.438	2.457	1.539	1.991
28	Manufacture of machinery and equipment	1.111	1.203	2.630	1.769	1.665
29	Manufacture of vehicles and trailers	1.667	1.403	2.189	1.310	1.540
30	Manufacture of other transport equipment	2.029	1.927	1.749	1.353	1.661
31	Manufacture of furniture	1.782	2.163	2.592	1.723	1.588
32	Other manufacturing	1.536	2.400	2.994	1.325	1.673
33	Repair and installation of equipment	1.659	2.282	2.371	1.524	1.673

Notes: All numbers are expressed in daily average wage, expressed in guilders for the Netherlands in 1820-1890 and Belgium for 1820 and expressed in francs for 1850-1890. Additionally, we expressed all wage rates as relative to the earned daily average wage in the lowest paid sector (so: lowest sector = 1.000). **Sources**: for Belgium and the Netherlands in 1820, we refer to Brugmans (1956). For Belgium in 1850 and 1890, the Belgian industry censuses of 1846 and 1896. For the Netherlands in 1890, the 1904 edition of the *Statistiek van de loonen der volgens de Ongevallenwet 1901 verzekerde werklieden, in de provincie Gelderland*.

Additionally, we include a set of control variables per region, on population, urbanization, and surface per province, as well as variables to account for pre-industrial development around ca. 1820 and alternative energy sources in 1850 and 1890. Statistics on urbanization (measured as the share of the population living in cities larger than 10,000 citizens as a share of total population within a province) and population are obtained from the 1846 and 1890 Belgian population censuses and the 1849 and 1889 Dutch population censuses. First, alternative energy sources in ca. 1850 and 1890. For coal output in Belgium in 1850, we use the study by Pluymers (1992). For 1890, we rely on the annual Belgian report of the Mining Administration or *Administration des mines*, a sub-office of the Ministry of Industry and Labor or *Ministère de l'industrie et du travail*.[58] For coal output in the Dutch province of Limburg during 1850 and 1890, the sole region producing coal in the Netherlands, we turn to the statistics collected by the TU Delft.[59] For peat output, we turn to the employment in peat extraction, as reported in the Belgian industry censuses of 1846 and 1896, for the Netherlands in ca. 1850 the 1857 report compiled by the Dutch Society for the Promotion of Industry (Nederlandsche Maatschappij 1859), and for the Netherlands in ca. 1890 the reconstructed industry census of 1896 (Philips 2019). For the number of water and wind mills, we turn for two datasets which document the in the mid-nineteenth century: the Belgian industry census of 1846 and the Dutch Mill Dataset.[60]

Furthermore, we collect proxy variables of pre-industrial development around ca. 1820. For proxies of demography, we collect data on the mortality and fertility rate in 1815, obtained from the statistical report *Opgave der Bevolking van het Koningrijk der Nederlanden.* For measures of agricultural development, we collect data on the produced hectolitres of grain per square hectare in 1812 and the employment in agriculture in 1810, estimated by Van Zanden (1985) and Goossens (1993).[61] For a measure of industrial development in 1820, we turn to the employment in industry per province from the industrial census conducted on 31 December 1819 in the former Dutch and Belgian United Kingdom of the Netherlands as published by Brugmans (1956). For an indicator on the access to domestic and foreign markets in ca. 1820, we turned to two variables. First, the exported tonnage of domestic and foreign ships in 1826, as reported in the *Proeve over de belangrijkheid van den handel, de scheepvaart en de nijverheid, in de gewesten die van 1813-1830*. Second, the kilometres of paved roads per square hectare 1820, for which we digitized the major paved roads from the 1816 topographical map *Algemeene Kaart van het Koninkrijk der Nederlanden.*

[58] *Statistique des mines, minières, carrières; usines métallurgiques et appareils a vapeur pour l'année* (1900).
[59] Coal production since the nineteenth century in the Netherlands, according to http://www.citg.tudelft.nl/index.php?id=18387&L=0/ .
[60] For more information, we refer to: https://www.molendatabase.nl/nederland/zoek.php .
[61] Van Zanden (1985: 91) provided only estimates on the hectolitres of grain per square hectare for the provinces of Drenthe, Overijssel, Gelderland, Groningen, Zeeland, and North Holland. To interpolate the missing provinces, we used the weighted average of the adjacent provinces for which we had data. Similarly, as data on employment in agriculture was not provided for all provinces by Van Zanden (1985: 43), we again used the weighted average of employment in agriculture for the adjacent provinces for which we had data.

4.5. Results

4.5.1. The effect of human capital during the first Industrial Revolution

In Table 20, we report the OLS and IV regressions for 580 observations, encompassing observations across 20 provinces in the Netherlands and Belgium and 29 industry sectors. In Columns 1-4, we measure the effect on the dependent variable, the number of installed steam engines in a particular sector and province, of the interaction between the average wage rate per sector and four different indicators of human capital per region: respectively the literacy rate (Column 1), the number of sold newspapers per capita (Column 2), the primary school enrolment (Column 3), and the secondary school enrolment (Column 4).

In Table 20, we start with a basic set-up in which we only control for basic measures per region: the size of the province, the size of the population, and the urbanization rate. We find that the size of the region is negatively associated with the number of installed steam engines in the estimates of all human capital proxies, whereas population and urbanization rate is positively associated with steam engines for some indicators of human capital. Furthermore, the results reveal for the first Industrial Revolution in the Netherlands and Belgium a contrasting picture: a negative association between literacy rates and sold newspapers with the number of installed steam engines, but a positive association between secondary school enrolment with the number of installed steam engines. The association between primary school enrolment and the steam engines appears insignificant.

However, as we outlined in Section 3, the OLS estimates might present biased results, as industrialization might not only be the result of changes in human capital, but also human capital might be influenced by the degree of industrialization. To resolve this issue of endogeneity, we instrument the human capital variables in 1850 with the human capital variables in 1820. Here, we hypothesize that at this point in time both countries faced itself at the beginning of the Industrial Revolution, when steam technology has been exogenously brought to the Low Countries from Britain, under the assumption that human capital in 1820 is not correlated with other variables in 1820 that can influence industrialization (an assumption which we deal with below). At the first stage (estimates available on request), we find human capital in 1820 a strong instrument for human capital in 1850. The second-stage estimate reveals a significant negative effect of literacy rates and a significant positive effect secondary school enrolment on the number of steam engines, but an insignificant effect of primary school enrolment and sold newspapers per capita.

Yet, for the level of human capital in 1820 to be a valid instrument, we have to assume that human capital in 1820 is not related to other variables in 1820 that might facilitate industrialization in 1850. Therefore, we extend in Table 21 the same model with a set of indicators that reflect economic development in 1820 and which might be conducive for industrialization in 1850. Here, we find that in all specifications, the tonnage of exports via ships in 1820 is negatively associated with the number of steam engines in 1850. Most plausible, we can hypothesize that centres of commerce specialized in trade-oriented occupations, whereas regions with a lack of trade activities specialized in industry. Furthermore, we find, with few exceptions, that most indicators of economic development in 1820 do not enter the model significantly. For instance, the effect of employment of industry in 1820 does not enter the model significantly in most specifications, which indicates that the process of industrialization which occurred during 1820-1850 fundamentally re-ordered the industry mix in the regions of the Low Countries. Yet, turning to the human capital variables, we find that the positive effect of secondary school enrolment and the effect of literacy rates on steam engines remain significantly robust.

Another issue is the spatial variation in the distribution of pre-industrial technology or natural resources, as both might hinder of facilitate the adoption of steam. Therefore, in Table 22, we control additionally for the output of coal and peat in a region, as well as the number of installed wind and water mills. Here, we find that the number of mills negatively affected the number of steam engines, thereby empirically confirming the view of Lintsen and Steenaard (1991) that the industrialization path of the Netherlands was hindered due to the abundance of this pre-industrial technology. Furthermore, not surprisingly, we confirm the positive association between the number of steam engines and coal output, as the operation costs of steam engines were highly dependent on this resource. Turning to our main variables of interest, we find that the negative effect of literacy rates on steam engines remains robust at the 5% level, in both the OLS and IV specification, whereas the positive effect of secondary school enrolment turns insignificant.

Table 20. Effect of human capital on steam engines during the first phase of industrialization (1850)

	dependent variable: ln Steam engines per capita 1850							
	OLS				IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Literacy	-0.121***				-0.127***			
x Skill intensity 1850	(0.0354)				(0.0351)			
Sold newspapers per capita		-0.0140***				-0.0128***		
x Skill intensity 1850		(0.00467)				(0.00427)		
Primary school enrolment			0.00152				-0.0750*	
x Skill intensity 1850			(0.0370)				(0.0392)	
Secondary school enrolment				2.632***				2.045**
x Skill intensity 1850				(0.943)				(1.035)
ln Region area (in 1000km^2)	-0.0919**	-0.0633*	-0.0718**	-0.116***	-0.0866***	-0.0746**	-0.0328	-0.0932**
	(0.0369)	(0.0327)	(0.0347)	(0.0406)	(0.0308)	(0.0297)	(0.0287)	(0.0402)
ln Population 1850	0.0244*	0.0472**	0.00824	0.0370*	0.0244**	0.0442**	-0.0195	0.0253
	(0.0121)	(0.0190)	(0.0190)	(0.0181)	(0.0109)	(0.0174)	(0.0169)	(0.0183)
Urbanisation rate 1850	0.105	0.248***	0.124	0.0290	0.103	0.252***	0.158**	0.0662
	(0.0732)	(0.0853)	(0.0786)	(0.0924)	(0.0694)	(0.0816)	(0.0713)	(0.0915)
Constant	0.873***	0.412*	0.612**	0.573**				
	(0.285)	(0.229)	(0.286)	(0.238)				
Country dummy	yes	yes	yes	yes	yes	yes	yes	yes
Sector dummies	yes	yes	yes	yes	yes	yes	yes	yes
F-statistic					4.04	4.29	3.38	2.90
p-value					0.0069	0.0051	0.0164	0.0311
Underidentification test					24.895	26.502	26.221	26.276
p-value					0.0000	0.0000	0.0000	0.0000
Weak identification test					6464.869	4771.484	1667.359	2251.258
Hansen J statistic					0.176	1.152	0.016	6.511
p-value					0.6750	0.2831	0.8997	0.0107
Endogeneity test					1.867	1.426	5.563	0.795
p-value					0.1718	0.2324	0.0183	0.3725
Observations	580	580	580	580	580	580	580	580
R-squared	0.447	0.441	0.432	0.444				

Notes: Columns (1) - (4) report the baseline OLS estimates. Columns (5) - (8) report the IV estimates, instrumented with the respective human capital variable in 1820. For simplicity, as it is not part of the main hypothesis, we do not include the individual covariate terms (the human capital per region and the skill intensity per sector) in the regression. All variables are in logarithm, using ln(x+1), except for percentage values and dummy variables. T-statistics are reported in brackets; standard errors are robust to control for heteroscedasticity. The asterisks denote significance levels, respectively for *** p<0.01, ** p<0.05, and * p<0.1.

Table 21. Effect of human capital on steam engines during the first phase of industrialization (1850), controlled for pre-industrial performance

	dependent variable: ln Steam engines per capita 1850							
	OLS				IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Literacy x Skill intensity 1850	-0.162**				-0.162***			
	(0.0612)				(0.0584)			
Sold newspapers per capita x Skill intensity 1850		-0.00761				-0.00303		
		(0.00456)				(0.00413)		
Primary school enrolment x Skill intensity 1850			0.138*				-0.0322	
			(0.0709)				(0.0492)	
Secondary school enrolment x Skill intensity 1850				3.422**				3.648***
				(1.245)				(1.303)
ln Region area (in 1000km^2)	-0.0340	-0.00462	-0.114	0.0318	-0.0355	-0.0159	0.00157	0.0498
	(0.0825)	(0.0841)	(0.110)	(0.0829)	(0.0774)	(0.0796)	(0.0840)	(0.0781)
ln Population 1850	0.0377	0.0166	0.0540	-0.0406	0.0362	-0.00580	-0.0149	-0.0567
	(0.0529)	(0.0527)	(0.0669)	(0.0489)	(0.0479)	(0.0490)	(0.0543)	(0.0456)
Urbanisation rate 1850	0.330**	0.320**	0.0994	0.127	0.329**	0.255*	0.275**	0.117
	(0.144)	(0.155)	(0.169)	(0.129)	(0.138)	(0.143)	(0.140)	(0.125)
Mortality rate 1820	5.045	5.950	4.853	9.812**	5.038	6.254*	6.748*	10.09**
	(3.725)	(3.719)	(4.106)	(4.298)	(3.565)	(3.515)	(3.903)	(4.114)
Fertility rate 1820	6.904*	2.710	-1.459	-10.70**	6.700*	-0.131	1.003	-12.40**
	(3.909)	(3.351)	(2.776)	(4.830)	(3.642)	(2.764)	(2.609)	(4.820)
Employment in industry 1820	1.339*	1.056	1.007	1.201*	1.361**	1.025	1.140*	1.467**
	(0.660)	(0.695)	(0.664)	(0.663)	(0.625)	(0.661)	(0.615)	(0.613)
Hectolitres of grain per square hectare 1820	0.0961	0.0908	0.112	0.190**	0.0987	0.0872	0.0829	0.214***
	(0.0668)	(0.0663)	(0.0688)	(0.0796)	(0.0629)	(0.0627)	(0.0630)	(0.0786)
Share employment in agriculture 1820	0.445*	0.135	-0.162	-0.0441	0.434**	0.0361	0.129	-0.0801
	(0.244)	(0.176)	(0.216)	(0.141)	(0.218)	(0.159)	(0.165)	(0.134)
Kilometres of paved roads per square hectare 1820	0.135	0.333	0.0305	0.630	0.154	0.413	0.331	0.756**
	(0.414)	(0.417)	(0.477)	(0.407)	(0.378)	(0.387)	(0.416)	(0.382)
Tonnage of exports via ships 1820	-0.0154***	-0.0126***	-0.0120***	-0.00723**	-0.0154***	-0.0105***	-0.0129***	-0.00620**
	(0.00480)	(0.00396)	(0.00383)	(0.00303)	(0.00455)	(0.00343)	(0.00379)	(0.00265)
Constant	-0.415	-0.349	-0.141	-0.0574				
	(0.539)	(0.569)	(0.482)	(0.478)				
Country dummy	yes	yes	yes	yes	yes	yes	yes	yes
Sector dummies	yes	yes	yes	yes	yes	yes	yes	yes
F-statistic					2.17	3.02	2.40	2.75
p-value					0.0452	0.0079	0.0279	0.0133
Underidentification test					23.459	25.336	26.066	25.833
p-value					0.0000	0.0000	0.0000	0.0000
Weak identification test					2763.812	4791.798	988.317	2816.435
Hansen J statistic					0.072	1.942	0.005	2.802
p-value					0.7890	0.1634	0.9434	0.0941
Endogeneity test					0.008	7.052	7.453	0.819
p-value					0.9286	0.0079	0.0063	0.3655
Observations	580	580	580	580	580	580	580	580
R-squared	0.475	0.465	0.468	0.475				

Notes: Columns (1) - (4) report the baseline OLS estimates. Columns (5) - (8) report the IV estimates, instrumented with the respective human capital variable in 1820. For simplicity, as it is not part of the main hypothesis, we do not include the individual covariate terms (the human capital per region and the skill intensity per sector) in the regression. All variables are in logarithm, using ln(x+1), except for percentage values and dummy variables. T-statistics are reported in brackets; standard errors are robust to control for heteroscedasticity. The asterisks denote significance levels, respectively for *** $p<0.01$, ** $p<0.05$, and * $p<0.1$.

Table 22. Effect of human capital on steam engines during the first phase of industrialization (1850), controlled for alternative energy sources

	dependent variable: ln Steam engines per capita 1850							
	OLS				IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Literacy	-0.0692**				-0.0787**			
x Skill intensity 1850	(0.0305)				(0.0346)			
Sold newspapers per capita		-0.00635				-0.00747**		
x Skill intensity 1850		(0.00374)				(0.00371)		
Primary school enrolment			0.0182				-0.0245	
x Skill intensity 1850			(0.0474)				(0.0378)	
Secondary school enrolment				0.559				0.269
x Skill intensity 1850				(0.810)				(0.884)
ln Region area (in 1000km^2)	-0.117**	-0.111**	-0.126**	-0.121**	-0.128***	-0.115***	-0.114***	-0.118***
	(0.0434)	(0.0427)	(0.0554)	(0.0448)	(0.0383)	(0.0390)	(0.0392)	(0.0427)
ln Population 1850	0.0313**	0.0441**	0.0317	0.0273	0.0333**	0.0475**	0.0184	0.0261
	(0.0150)	(0.0193)	(0.0272)	(0.0164)	(0.0139)	(0.0186)	(0.0193)	(0.0159)
Urbanisation rate 1850	0.164**	0.229**	0.173*	0.165*	0.165**	0.242***	0.185**	0.173**
	(0.0752)	(0.0922)	(0.0864)	(0.0873)	(0.0705)	(0.0881)	(0.0780)	(0.0848)
ln Output of coal 1850	0.0126***	0.0140***	0.0152***	0.0144***	0.0125***	0.0136***	0.0149***	0.0147***
	(0.00412)	(0.00413)	(0.00462)	(0.00408)	(0.00399)	(0.00389)	(0.00402)	(0.00382)
ln Output of peat 1850	-0.00328	-0.00582	-0.00792	-0.00703	-0.00331	-0.00576	-0.00660	-0.00701*
	(0.00452)	(0.00436)	(0.00546)	(0.00426)	(0.00447)	(0.00413)	(0.00419)	(0.00403)
ln Number of mills 1850	-0.0201**	-0.0243**	-0.0236**	-0.0196*	-0.0201**	-0.0238***	-0.0244***	-0.0216*
	(0.00983)	(0.00957)	(0.00970)	(0.0110)	(0.00946)	(0.00904)	(0.00902)	(0.0112)
Constant	0.986***	0.804***	0.891***	0.898***				
	(0.309)	(0.290)	(0.300)	(0.298)				
Country dummy	yes	yes	yes	yes	yes	yes	yes	yes
Sector dummies	yes	yes	yes	yes	yes	yes	yes	yes
F-statistic					3.16	3.23	3.07	2.82
p-value					0.0112	0.0099	0.0130	0.0198
Underidentification test					24.829	26.465	25.806	25.946
p-value					0.0000	0.0000	0.0000	0.0000
Weak identification test					4922.338	4872.759	966.155	1997.215
Hansen J statistic					0.556	0.243	0.443	0.000
p-value					0.4557	0.6224	0.5056	0.9972
Endogeneity test					0.656	2.886	1.453	1.035
p-value					0.4180	0.0894	0.2281	0.3090
Observations	580	580	580	580	580	580	580	580
R-squared	0.485	0.482	0.481	0.481				

Notes: Columns (1) - (4) report the baseline OLS estimates. Columns (5) - (8) report the IV estimates, instrumented with the respective human capital variable in 1820. For simplicity, as it is not part of the main hypothesis, we do not include the individual covariate terms (the human capital per region and the skill intensity per sector) in the regression. All variables are in logarithm, using ln(x+1), except for percentage values and dummy variables. T-statistics are reported in brackets; standard errors are robust to control for heteroscedasticity. The asterisks denote significance levels, respectively for *** p<0.01, ** p<0.05, and * p<0.1.

To summarize, we find in Tables 20-22 a negative significant effect of literacy rates on the number of steam engines, whereas the effect of primary school enrolment, secondary school enrolment, and sold newspapers per capita appear insignificant throughout all specifications combined. As such, the negative insignificant effect confirms the literature that downsized the role that human capital might have played in the first Industrial Revolution (e.g., Mitch 1999; Crafts 1996; Clark 2005) and the studies that argued that the technology-skill complementary was absent during the first Industrial Revolution (Galor and Moav 2006; De Pleijt and Weisdorf 2017; De Pleijt et al. 2019). The stimulus could have been twofold. On the one hand, in regions with a higher illiterate labour force more cheap female and child labour workers could be found, in line with the recent work of Humphries and Schneider (2018) on the English countryside. On the other hand, these results affirm the studies which argued that regions where labour was abundant and cheap were more likely to industrialize (e.g. Pollard 1978).

Furthermore, for the Netherlands and Belgium, we empirically confirm the historiography in Netherlands (e.g. Keuning 1955; De Jong and Van Zanden 2015) and Belgium (e.g. De Brabander 1983) which argued that the first Industrial Revolution mainly benefitted the regions with unskilled and cheap labour. Based on Figure 23, this concerned predominantly the southern and eastern regions in the Netherlands, and Wallonia in Belgium. Given the higher illiterate rate of most Belgian provinces compared to nearly all Dutch provinces during the first half of the nineteenth century, our evidence asserts that human capital played an influence in the earlier offset of industrialization in Belgium compared to its northern neighbour. Indirectly, assuming wage levels to reflect skill intensities, we confirm those studies which stressed the lower wage rate being instrumental to the earlier Industrial Revolution in Belgium compared to the Netherlands (Mokyr 1974, 1976; Van Houtte 1972; Bos 1979; Griffiths 1979).

4.5.2. The effect of human capital during the second phase of industrialization

Next, we repeat our specifications for testing the effect of human capital during the second phase of industrialization. In Table 23, we report the effect of human capital in 1890 on steam engines per capita in 1890, similar to the model in Table 20, with one exception: by including next to the basic measures per region, also the number of steam engines per capita in 1850 as to isolate the effect of human capital on the number of steam engines which became installed during 1850-1890. In Columns 1-4 of Table 23, we find that all proxies of human capital are positive and significant, at least at the 10% significance level. Furthermore, we find that the steam engines per capita in 1850 had an insignificant effect on the steam engines per capita in 1890, confirming that the second Industrial Revolution introduced a different industry mix and geographical variation compared to the one of the first Industrial Revolution. To establish endogeneity, we repeat the estimation by instrumenting the human capital variables in 1890 with the level of human capital variables in 1820, when the Low Countries faced itself at the beginning of the Industrial Revolution. Here, we find again that all human capital indicators are significant and positive to the steam engines per capita in 1890, at least at the 10% significance level.

As we can assume that the validity of human capital in 1820 as an instrument depends on other indicators of economic development in 1820, we can hence expect the possibility of a biased instrument. Therefore, we extend in Table 24 the previous model with a list of indicators of economic development in 1820. Throughout Columns 1-8 of Table 24, we find a significant positive effect of hectolitres grain per square hectare in 1820, our proxy of agricultural productivity. Here, we can hypothesize that given the mechanization of lighter industries such as the production of foodstuffs during the second Industrial Revolution, regions with a comparative advantage in agriculture adopted more steam engines. Yet, for the other indicators of economic development in 1820, we find for no indicator a significant effect throughout all specifications. Turning to our variables of interest, we find that the positive effect of primary school enrolment drops under the 10% significance level in Column 7. Yet, the positive effect of literacy rates, sold newspapers per capita, and secondary school enrolment remain robust, both in the OLS and IV estimates.

In Table 25, we repeat the model, now by controlling in addition for pre-industrial technology and natural resources. Here, we include the coal output and peat output in 1890. As data on the number of mills installed in 1890 remain absent to our knowledge, we include the number of wind and water mills installed in 1850. We find in Columns 1-3 and 5-7 of Table 25 a negative effect of the number of water and wind mills in 1850 on the number of steam engines per capita in 1890. As such, the availability of this pre-industrial technology remained to exert a delayed transition to steam until deep into the nineteenth century. Yet, with the exception of Column 8, we find an insignificant association of coal and peat output in 1890 with steam engines per capita, in contrast to our findings in Table 23. As such, we can hypothesize that the fall of transport costs removed the incentives of industries to locate near centres of coal production, an observation in line with the findings of Ronsse and Rayp (2016) for early twenty-century Belgium. Turning to the effect of human capital, we find that the positive effect of literacy rates and primary school enrolment on steam engines per capita drop under the 10% significance levels, whereas the positive effect of secondary school enrolment and sold newspapers per capita remains positive and significant.

All in all, we find a positive significant effect of secondary school enrolment and sold newspapers per capita on steam engines per capita throughout all specifications of the model, whereas the effect of literacy rates and primary school enrolment appear insignificant, the latter depending on the empirical specification. As such, we confirm the studies that argued in favour of a positive effect of human capital during the second phase of industrialization, in particular those studies which supported a technology-skill complementary (e.g., Goldin and Katz 1998; Acemoglu 2002; Galor and Moav 2006), a finding shared for early twentieth century Belgium (Van Meerten 2000) and the Netherlands (De Jong 1999). As such, our findings complement the findings of Becker et al. (2011) and Squicciarini and Voigtländer (2015), who found a causal positive effect of human capital on industrialization in respectively nineteenth century Prussia and France.

Furthermore, our results offer an alternative explanation for the literature in the Netherlands and Belgium that stressed a shift in the location of industry during the second Industrial Revolution. For the Netherlands, the studies of Brugmans (1969) and Atzema and Wever (1994) argued that a geographical shift of industries took place from the eastern and southern regions to the more urbanised western provinces, the North Holland and South Holland provinces, a transition that Bos (1976) entitled as a "periphery to centre" shift. Likewise, De Brabander (1983), Ronsse and Rayp (2016), and Buyst (2018) observed in Belgium a comparable relocation of the industrial heartland in Belgium, from the Hainaut and Liège provinces to the Antwerp and Brabant provinces. As both the Holland provinces in the Netherlands and the Antwerp and Brussels provinces in Belgium seem to hold the highest shares of secondary school enrolment and sold newspapers per capita (see Figure 23), it appears that human capital played a notable part in the relocation of the industrial heartland of both countries during the second phase of industrialization.

Table 23. Effect of human capital on steam engines during the second phase of industrialization (1890)

	dependent variable: ln Steam engines per capita 1890							
	OLS				IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Literacy	0.227*				0.262**			
x Skill intensity 1890	(0.128)				(0.133)			
Sold newspapers per capita		0.0231***				0.0285***		
x Skill intensity 1890		(0.00819)				(0.00887)		
Primary school enrolment			0.353**				0.283*	
x Skill intensity 1890			(0.167)				(0.158)	
Secondary school enrolment				2.791***				2.266**
x Skill intensity 1890				(0.884)				(1.053)
ln Region area (in 1000km^2)	0.174***	0.211***	0.150***	0.254***	0.165***	0.225***	0.154***	0.245***
	(0.0520)	(0.0577)	(0.0497)	(0.0637)	(0.0467)	(0.0549)	(0.0450)	(0.0612)
ln Population 1890	-0.137**	-0.201***	-0.109*	-0.156**	-0.124**	-0.199***	-0.110**	-0.166***
	(0.0582)	(0.0626)	(0.0589)	(0.0579)	(0.0523)	(0.0608)	(0.0534)	(0.0541)
Urbanisation rate 1890	0.142	0.0998	0.0818	0.0940	0.121	0.0727	0.0763	0.126
	(0.114)	(0.117)	(0.127)	(0.113)	(0.105)	(0.113)	(0.113)	(0.112)
ln Steam engines per capita	57.44	60.47	61.92	46.85	72.18	91.36	68.12	45.23
1850	(74.07)	(74.45)	(74.88)	(71.66)	(66.32)	(68.36)	(71.32)	(68.00)
Constant	0.138	0.666	-0.0585	-0.0715				
	(0.616)	(0.573)	(0.639)	(0.600)				
Country dummy	yes	yes	yes	yes	yes	yes	yes	yes
Sector dummies	yes	yes	yes	yes	yes	yes	yes	yes
F-statistic					5.25	5.35	4.57	3.62
p-value					0.0010	0.0009	0.0024	0.0088
Underidentification test					17.771	25.967	21.264	27.337
p-value					0.0001	0.0000	0.0000	0.0000
Weak identification test					2407.575	2243.369	1157.590	730.653
Hansen J statistic					0.429	2.752	0.272	1.064
p-value					0.5124	0.0971	0.6023	0.3023
Endogeneity test					1.107	0.838	2.668	0.838
p-value					0.2926	0.3598	0.1024	0.3599
Observations	580	580	580	580	580	580	580	580
R-squared	0.500	0.502	0.503	0.505				

Notes: Columns (1) - (4) report the baseline OLS estimates. Columns (5) - (8) report the IV estimates, instrumented with the respective human capital variable in 1820. For simplicity, as it is not part of the main hypothesis, we do not include the individual covariate terms (the human capital per region and the skill intensity per sector) in the regression. All variables are in logarithm, using ln(x+1), except for percentage values and dummy variables. T-statistics are reported in brackets; standard errors are robust to control for heteroscedasticity. The asterisks denote significance levels, respectively for *** p<0.01, ** p<0.05, and * p<0.1.

Table 24. Effect of human capital on steam engines during the second phase of industrialization (1890), controlled for pre-industrial economic performance

	dependent variable: ln Steam engines per capita 1890							
	OLS				IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Literacy	0.256*				0.275**			
x Skill intensity 1850	(0.127)				(0.131)			
Sold newspapers per capita		0.0227**				0.0236**		
x Skill intensity 1850		(0.00943)				(0.00953)		
Primary school enrolment			0.293*				0.167	
x Skill intensity 1850			(0.165)				(0.156)	
Secondary school enrolment				3.171***				2.992**
x Skill intensity 1850				(1.132)				(1.297)
ln Region area (in 1000km^2)	0.383***	0.393***	0.355***	0.379***	0.370***	0.426***	0.361***	0.368***
	(0.106)	(0.107)	(0.107)	(0.106)	(0.0976)	(0.0921)	(0.102)	(0.0972)
ln Population 1890	-0.258***	-0.299***	-0.235***	-0.221**	-0.250***	-0.310***	-0.244***	-0.210***
	(0.0809)	(0.0803)	(0.0837)	(0.0830)	(0.0754)	(0.0750)	(0.0803)	(0.0746)
Urbanisation rate 1890	0.203	0.160	0.180	-0.0127	0.176	0.176	0.185	-0.0306
	(0.171)	(0.177)	(0.179)	(0.194)	(0.156)	(0.169)	(0.171)	(0.186)
ln Steam engines per capita	50.70	55.75	56.63	42.55	43.69	71.88	59.68	48.18
1890	(69.92)	(70.80)	(70.85)	(70.02)	(65.10)	(63.92)	(67.44)	(65.92)
Mortality rate 1820	0.0311	2.338	-0.508	-7.989	-1.074	4.387	1.886	-7.811*
	(4.979)	(5.107)	(4.963)	(5.745)	(4.110)	(4.054)	(4.333)	(4.719)
Fertility rate 1820	-12.93*	-10.43	-11.82	-9.462	-13.30**	-10.82	-12.46*	-9.327
	(7.081)	(7.467)	(7.205)	(7.585)	(6.674)	(7.033)	(6.816)	(7.188)
Employment in industry	0.814	0.820	0.824	1.124*	0.867	0.694	0.709	1.098*
1820	(0.587)	(0.608)	(0.594)	(0.602)	(0.531)	(0.553)	(0.564)	(0.563)
Hectolitres of grain per	0.326***	0.318***	0.304***	0.247***	0.323***	0.320***	0.297***	0.238***
square hectare 1820	(0.0728)	(0.0724)	(0.0734)	(0.0746)	(0.0687)	(0.0685)	(0.0694)	(0.0684)
Share employment in	-0.0706	-0.0383	-0.121	-0.146	-0.0975	-0.0608	-0.0933	-0.213
agriculture 1820	(0.193)	(0.194)	(0.192)	(0.192)	(0.172)	(0.180)	(0.179)	(0.165)
Kilometres of paved roads	0.691	0.296	0.611	0.326	0.626	0.417	0.627	0.229
per square hectare 1820	(0.507)	(0.586)	(0.518)	(0.557)	(0.454)	(0.536)	(0.490)	(0.500)
Tonnage of exports via	-0.00361	-0.00538	-0.00408	0.00252	-0.00295	-0.00528	-0.00335	0.00337
ships 1820	(0.00452)	(0.00465)	(0.00453)	(0.00462)	(0.00408)	(0.00438)	(0.00425)	(0.00444)
Constant	-0.548	-0.158	-0.519	-0.401				
	(0.609)	(0.535)	(0.607)	(0.555)				
Country dummy	yes	yes	yes	yes	yes	yes	yes	yes
Sector dummies	yes	yes	yes	yes	yes	yes	yes	yes
F-statistic					6.77	5.63	6.55	5.49
p-value					0.0000	0.0001	0.0000	0.0001
Underidentification test					13.759	24.251	23.844	26.891
p-value					0.0010	0.0000	0.0000	0.0000
Weak identification test					3431.232	3835.103	4691.375	457.375
Hansen J statistic					0.220	0.608	1.518	0.767
p-value					0.6387	0.4356	0.2179	0.3813
Endogeneity test					0.554	0.007	5.903	0.150
p-value					0.4565	0.9339	0.0151	0.6982
Observations	580	580	580	580	580	580	580	580
R-squared	0.518	0.518	0.517	0.521				

Notes: Columns (1) - (4) report the baseline OLS estimates. Columns (5) - (8) report the IV estimates, instrumented with the respective human capital variable in 1820. For simplicity, as it is not part of the main hypothesis, we do not include the individual covariate terms (the human capital per region and the skill intensity per sector) in the regression. All variables are in logarithm, using ln(x+1), except for percentage values and dummy variables. T-statistics are reported in brackets; standard errors are robust to control for heteroscedasticity. The asterisks denote significance levels, respectively for *** p<0.01, ** p<0.05, and * p<0.1.

Table 25. Effect of human capital on steam engines during the second phase of industrialization (1890), controlled for alternative energy sources

	dependent variable: ln Steam engines per capita 1890							
	OLS				IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Literacy	0.193				0.222*			
x Skill intensity 1850	(0.129)				(0.134)			
Sold newspapers per capita		0.0261***				0.0302***		
x Skill intensity 1850		(0.00893)				(0.00957)		
Primary school enrolment			0.310*				0.287*	
x Skill intensity 1850			(0.170)				(0.162)	
Secondary school enrolment				2.380**				2.583**
x Skill intensity 1850				(1.044)				(1.204)
ln Region area (in 1000km^2)	0.119**	0.152***	0.110**	0.214***	0.114***	0.157***	0.116***	0.174**
	(0.0469)	(0.0513)	(0.0461)	(0.0650)	(0.0429)	(0.0491)	(0.0432)	(0.0763)
ln Population 1890	-0.0653	-0.132**	-0.0548	-0.115**	-0.0596	-0.116**	-0.0514	-0.0882
	(0.0518)	(0.0555)	(0.0526)	(0.0497)	(0.0467)	(0.0523)	(0.0493)	(0.0557)
Urbanisation rate 1890	-0.0976	-0.151	-0.0966	-0.0320	-0.111	-0.222	-0.0961	-0.106
	(0.152)	(0.154)	(0.151)	(0.140)	(0.140)	(0.144)	(0.143)	(0.104)
ln Steam engines per capita 1850	50.45	44.11	52.15	47.33	55.40	64.27	38.78	36.34
	(70.55)	(68.56)	(70.95)	(70.04)	(64.05)	(64.28)	(66.74)	(66.69)
ln Output of coal 1890	-0.000399	0.00137	0.000529	-0.000750	-0.000684	0.00109	0.00101	-0.00153**
	(0.00278)	(0.00281)	(0.00273)	(0.00285)	(0.00264)	(0.00265)	(0.00256)	(0.00612)
ln Output of peat 1890	0.00816	0.00804	0.00556	0.00474	0.00841	0.0103*	0.00709	0.00167**
	(0.00595)	(0.00595)	(0.00622)	(0.00620)	(0.00560)	(0.00551)	(0.00576)	(0.00785)
ln Number of mills 1850	-0.0157**	-0.0229***	-0.0185**	-0.0610	-0.0153***	-0.0237***	-0.0168***	-0.0379
	(0.0586)	(0.0811)	(0.0697)	(0.0520)	(0.0544)	(0.0777)	(0.0651)	(0.0650)
Constant	-0.220	0.301	-0.322	-0.222				
	(0.607)	(0.557)	(0.620)	(0.583)				
Country dummy	yes	yes	yes	yes	yes	yes	yes	yes
Sector dummies	yes	yes	yes	yes	yes	yes	yes	yes
F-statistic					5.35	4.00	4.00	3.91
p-value					0.0003	0.0022	0.0022	0.0026
Underidentification test					16.669	25.434	12.383	27.098
p-value					0.0002	0.0000	0.0020	0.0000
Weak identification test					2293.359	2363.693	1360.107	501.141
Hansen J statistic					0.080	3.079	1.513	3.819
p-value					0.7768	0.0793	0.2186	0.0507
Endogeneity test					0.839	0.262	0.970	0.154
p-value					0.3597	0.6089	0.3246	0.6944
Observations	580	580	580	580	580	580	580	580
R-squared	0.504	0.509	0.506	0.506				

Notes: Columns (1) - (4) report the baseline OLS estimates. Columns (5) - (8) report the IV estimates, instrumented with the respective human capital variable in 1820. For simplicity, as it is not part of the main hypothesis, we do not include the individual covariate terms (the human capital per region and the skill intensity per sector) in the regression. All variables are in logarithm, using ln(x+1), except for percentage values and dummy variables. T-statistics are reported in brackets; standard errors are robust to control for heteroscedasticity. The asterisks denote significance levels, respectively for *** p<0.01, ** p<0.05, and * p<0.1.

4.5.3. Robustness checks

Finally, in Tables 26 and 27, we report two sets of robustness checks. In Table 26, we control for religion, as Becker and Woessman (2009) and Squicciarini (2019) pointed to the link between religion and nineteenth century industrial development. For this, we include the share of Jewish and protestant population, which could be retrieved from the population censuses. Although we find that the share of the protestant population was positively associated with steam engines installation during the second phase of industrialization, the negative significant effect of literacy during the first phase of industrialization and the positive significant effect of secondary school enrolment and sold newspapers per capita during the second phase of industrialization on steam engines per capita remains robust at the 5% level.

As an additional robustness test, in Table 27, we control for geography. We augment the model with longitude, latitude, the distance to Brussels and Amsterdam (as the distance to the Belgian and Dutch capital could have implicated a higher receptiveness to steam technology), and the distance to London (to account for the distance from Britain, the place where the technology originated). Our results indicate a positive effect of the distance to London on steam engines per capita for the first phase of industrialization, as well as a negative effect of latitude and longitude. Neither of these effects are found significant for the second phase of industrialization. Yet, we find that the found effects of human capital remain robust at the at the 5% level once controlled for geography.

Table 26. Robustness check, controlling for culture, for the effect of human capital on steam engines during the first and second phase of industrialization

	dependent variable: ln Steam engines per capita 1850				dependent variable: ln Steam engines per capita 1890			
	OLS				IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Literacy x Skill intensity 1850	-0.112**				0.281**			
	(0.0473)				(0.127)			
Sold newspapers per capita x Skill intensity 1850		-0.00560				0.0232**		
		(0.00809)				(0.00916)		
Primary school enrolment x Skill intensity 1850			0.0860*				0.338*	
			(0.0467)				(0.167)	
Secondary school enrolment x Skill intensity 1850				2.164**				3.151***
				(0.961)				(0.847)
Share of protestant population	-0.00767	-0.0154	-0.0252**	-0.0187**	0.0520***	0.0414***	0.0435***	0.0508***
	(0.0119)	(0.0158)	(0.0102)	(0.00884)	(0.0138)	(0.0145)	(0.0142)	(0.0139)
Share of Jewish population	0.406	-1.179	-1.970**	-0.755	1.737**	2.421**	1.208	1.143
	(0.868)	(0.804)	(0.924)	(0.917)	(0.829)	(0.930)	(0.795)	(0.822)
ln Region area (in 1000km^2)	-0.0905***	-0.0470	-0.0779**	-0.0896**	0.135**	0.185***	0.124**	0.229***
	(0.0303)	(0.0277)	(0.0361)	(0.0357)	(0.0517)	(0.0595)	(0.0507)	(0.0631)
ln Population 1850	0.0266*	0.0159	0.0257	0.0275	-0.0792	-0.158**	-0.0653	-0.104*
	(0.0154)	(0.0251)	(0.0219)	(0.0226)	(0.0578)	(0.0658)	(0.0585)	(0.0577)
Urbanisation rate 1850	0.107	0.296**	0.290***	0.153	-0.238	-0.232	-0.220	-0.264*
	(0.108)	(0.114)	(0.104)	(0.130)	(0.150)	(0.145)	(0.147)	(0.141)
ln Steam engines per capita 1850					60.17	66.61	66.30	48.33
					(70.74)	(72.45)	(72.22)	(67.69)
Constant	0.799***	0.444*	0.252	0.464*	-0.140	0.481	-0.227	-0.342
	(0.268)	(0.243)	(0.260)	(0.233)	(0.611)	(0.572)	(0.632)	(0.592)
Country dummy	yes	yes	yes	yes	yes	yes	yes	yes
Sector dummies	yes	yes	yes	yes	yes	yes	yes	yes
Observations	580	580	580	580	580	580	580	580
R-squared	0.448	0.444	0.445	0.450	0.512	0.510	0.511	0.516

Notes: Columns (1) - (8) report the baseline OLS estimates. For simplicity, as it is not part of the main hypothesis, we do not include the individual covariate terms (the human capital per region and the skill intensity per sector) in the regression. All variables are in logarithm, using ln(x+1), except for percentage values and dummy variables. T-statistics are reported in brackets; standard errors are robust to control for heteroscedasticity. The asterisks denote significance levels, respectively for *** p<0.01, ** p<0.05, and * p<0.1.

Table 27. Robustness check, controlling for geography, for the effect of human capital on steam engines during the first and second phase of industrialization

	dependent variable: ln Steam engines per capita 1850				dependent variable: ln Steam engines per capita 1890			
	OLS				IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Literacy x Skill intensity 1850	-0.101*** (0.0348)				0.288** (0.129)			
Sold newspapers per capita x Skill intensity 1850		-0.0111** (0.00467)				0.0236** (0.0102)		
Primary school enrolment x Skill intensity 1850			-0.0405 (0.0371)				0.418** (0.167)	
Secondary school enrolment x Skill intensity 1850				2.996* (1.608)				4.794*** (1.034)
ln Distance to Brussels	-0.00826 (0.00577)	-0.0230*** (0.00692)	-0.0188*** (0.00622)	0.00150 (0.0119)	0.00129 (0.00855)	-0.00146 (0.00866)	-0.00228 (0.00859)	0.0211* (0.0115)
ln Distance to Amsterdam	0.00164 (0.00769)	0.00724 (0.00820)	0.00852 (0.00889)	-0.00509 (0.0121)	-0.0156 (0.00963)	-0.0247** (0.0114)	-0.0143 (0.00967)	0.00489 (0.00903)
ln Distance to London	0.559** (0.210)	0.652*** (0.223)	0.796*** (0.237)	0.465** (0.220)	-0.505 (0.302)	-0.155 (0.318)	-0.433 (0.300)	-0.590* (0.307)
Latitude	-0.373*** (0.000127)	-0.437*** (0.000138)	-0.373*** (0.000132)	-0.358*** (0.000121)	-0.0375* (0.000205)	-0.0374* (0.000205)	-0.043** (0.000199)	-0.0515** (0.000201)
Longitude	-0.103** (0.0453)	-0.133** (0.0493)	-0.157*** (0.0522)	-0.108** (0.0464)	0.0898 (0.0665)	0.0264 (0.0697)	0.0774 (0.0668)	0.0705 (0.0671)
ln Region area (in 1000km^2)	-0.134** (0.0550)	-0.0845* (0.0479)	-0.0989** (0.0478)	-0.151** (0.0568)	0.224*** (0.0611)	0.245*** (0.0644)	0.195*** (0.0591)	0.380*** (0.0766)
ln Population 1850	0.0542 (0.0417)	0.0455 (0.0426)	0.0238 (0.0387)	0.0581 (0.0451)	-0.173** (0.0633)	-0.226*** (0.0681)	-0.140** (0.0635)	-0.235*** (0.0658)
Urbanisation rate 1850	0.160* (0.0792)	0.322*** (0.110)	0.254** (0.0919)	0.0508 (0.150)	0.0687 (0.120)	0.0264 (0.124)	-0.0137 (0.132)	0.0903 (0.118)
ln Steam engines per capita 1850					53.18 (72.09)	55.58 (71.94)	57.17 (72.62)	30.81 (66.21)
Constant	-1.701* (0.992)	-2.254** (1.019)	-2.893** (1.072)	-1.351 (0.968)	3.034* (1.532)	1.913 (1.622)	2.536 (1.556)	3.300** (1.574)
Country dummy	yes	yes	yes	yes	yes	yes	yes	yes
Sector dummies	yes	yes	yes	yes	yes	yes	yes	yes
Observations	580	580	580	580	580	580	580	580
R-squared	0.469	0.465	0.462	0.468	0.509	0.507	0.511	0.520

Notes: Columns (1) - (8) report the baseline OLS estimates. For simplicity, as it is not part of the main hypothesis, we do not include the individual covariate terms (the human capital per region and the skill intensity per sector) in the regression. All variables are in logarithm, using ln(x+1), except for percentage values and dummy variables. T-statistics are reported in brackets; standard errors are robust to control for heteroscedasticity. The asterisks denote significance levels, respectively for *** p<0.01, ** p<0.05, and * p<0.1.

4.6. Conclusion

Human capital is generally considered an important factor for industrial growth. Yet, studies are far from univocal. While some studies argue in favour, others find no, or even a negative effect. One of the latter examples are the Low Countries. With the relatively early industrialized Belgium having low levels of literacy rates compared to the highly literate but rather late industrializing Netherlands, some authors have argued for a lack of an effect of human capital on industrialization in these regions. Yet, with influential studies finding human capital instrumental for industrialization in 19th century France (Squicciarini and Voigtländer 2015) and Prussia (Becker et al. 2011; Franck and Galor 2018), it sounds strange that this were not to be the case for these two countries.

We tested the effect of human capital on the number of steam engines per capita in the Netherlands and Belgium during the first Industrial Revolution (1820-1850) and second phase of industrialization (1850-1890). Our results indicate a negative significant effect of literacy rates on the number of steam engines during the first Industrial Revolution, but a significant positive effect of secondary school enrolment and sold newspapers per capita on the number of steam engines during the second phase of industrialization. As steam engines were introduced as an import product for these regions from Britain, we assume that steam engines arrive exogenously to most regions. In addition, these results remain robust once we establish causation by instrumenting the level of human capital in 1850 and 1890 with the level of human capital in 1820, the time when steam was introduced to the Low Countries. Even so, our results remained robust once controlled for additional indicators of economic development in 1820, to ensure the robustness of our instrumentation by human capital in 1820, pre-industrial technology such as wind and water mills, and the availability of natural resources such as peat and coal. Additionally, introducing robustness checks to control for culture and geography do not influence our findings.

As a general conclusion, we argue that our evidence demonstrates that the first Industrial Revolution (1820-1850) inhabited for the Low Countries a period in which low-skill intensive industries predominantly set up location in regions with a low amount of human capital. In contrast, the second phase of industrialization introduced for both regions a technology-skill complementary, with high-skill intensive industries locating near regions with high human capital stocks. As such, we provide an alternative explanation for the earlier industrial take-off of Belgium compared to its northern neighbour, as the first country benefitted from its relatively higher human capital rate. Additionally, we explain regional trends in industrialization as noted in the historiography in both countries: in Belgium with the emergence of Hainaut and Liège during the first Industrial Revolution and the Brabant-Antwerp axis during the second phase of industrialization, the former regions encompassing the regions with the lowest literacy rates and the latter the regions with the highest secondary school enrolment rates and newspaper subscriptions per capita. Similarly, in the Netherlands with growth for the eastern and southern regions during the first Industrial Revolution and the Holland provinces during the second phase of industrialization.

Lastly, on a methodological level, our estimates introduce a systematic test of four indicators of human capital: literacy rates, primary school enrolment, secondary school enrolment, and sold newspapers per capita. Given the found variation in empirical results over these different indicators of human capita, depending on the empirical specification, our study emphasizes the carefulness a researcher must commit when interpreting proxies of human capital. Given the changes in schooling and skills over the nineteenth century, as well as the changes in the democratization of education, our evidence underlines the need for a clear argumentation about the selection of a proxy for human capital. Additionally, the findings of Becker et al. (2011) make us aware of the importance of studying intersectoral effects with the effect of human capital. By taking the wage rate per industry sector as a proxy for the skill level in a particular industry sector, we tried to account for such an effect. Yet, given the lack of studies dealing with such intersectoral effects, we hope these findings might stimulate further studies on this line of research.

Chapter 5. The transition during the long twentieth century

(together with Glenn Rayp and Stijn Ronsse)[62]

5.1. Introduction: factor endowments versus new economic geography

Although the location of industry has always attracted the attention of economists and economic historians alike, the last three decades have introduced a boom in both theoretical and empirical contributions in this line of research. For long, the role of comparative advantage and differences in the availability of factor endowments remained the most influential explanation of why regions specialized in particular industry sectors (see e.g. Brülhart 1998). During the 1990s, New Economic Geography studies (see e.g. Krugman 1991; Krugman and Venables 1995) challenged this one-sided explanation, by stressing the effects of the access to domestic and international markets. With the publications of Kim (1995; 1998) and Davis and Weinstein (1999; 2003), models were developed that tested the relative importance of the Heckscher-Ohlin (HO) theorem, as the main example of the neo-classical trade theory, and the New Economic Geography (NEG) theorem, to check for the importance of Marshallian or agglomeration forces. However, it took until the development of the Midelfart-Knarvik et al. model (2000; 2002a; 2002b) that an integrated model was developed to estimate the relative weight of HO and NEG determinants in explaining the location of industry.

Retrospectively, the Midelfart-Knarvik et al. (2000; 2002a; 2002b) model proved a milestone for the study of the location of industry in the field of economic history. In its wake, a multitude of economic history studies arose which applied the model, for e.g.: Britain (Crafts and Mulatu 2005), Poland (Wolf 2007), Spain (Martinez-Galarraga 2012), USA (Klein and Crafts 2012), Belgium (Ronsse and Rayp 2016), Yugoslavia (Nikolic 2018), and Italy (Missiaia 2019). Nevertheless, besides that these studies have empirically proven that both NEG and HO factors can explain the location of industry, not much can be concluded from the

[62] This chapter is largely based upon the following working paper: Philips, R., Rayp, G. and Ronsse, S. "The Determinants of Industrial Location in the Low Countries (1890 - 1970)". Furthermore, we would like to thank the Historical Database of Local and Cadastral Statistics LOKSTAT-POPPKAD (Quetelet Center, Ghent University), specifically Sven Vrielinck, and the Historical Sample of the Netherlands (HSN), specifically Kees Mandemakers, for providing data. Additionally, we want to thank Bas van Leeuwen and Jan Luiten van Zanden for comments, as well as the participants of the 11th BETA workshop in historical economics at Strasbourg University.

aforementioned studies in terms of the relative weight of Heckscher-Ohlin and New Economic Geography factors over time. For instance, while some studies found a predominant effect of Heckscher-Ohlin factors (Crafts and Mulatu 2005; Missiaia 2019), other studies found evidence for a predominant effect of New Economic Geography factors (Klein and Crafts 2012; Ronsse and Rayp 2016; Nikolic 2018), with the findings of Wolf (2007) and Martinez-Galarraga (2012) presenting a more balanced view. In addition, whereas most studies found that New Economic Geography factors increased in importance over time (Wolf 2007; Klein and Crafts 2012; Martinez-Galarraga 2012; Ronsse and Rayp 2016; Missiaia 2019), Crafts and Mulatu (2005) found evidence for an opposite trend.[63]

As a result, the relative importance of Heckscher-Ohlin and New Economic Geography forces remains a topic of debate, where we can hypothesize about two reasons for this ambiguity. First, for reasons of data availability, all publications studied the location of industry over a relatively short time span within a single country. As a result of the non-negligible variability in both data and methodology, comparisons over countries are difficult to make. For instance, the use of different methodologies to measure market potential is argued to complicate interpreting the importance of New Economic Geography factors (Rayp and Ronsse 2019). In addition, as the period under study covered for most studies relative short periods of time, predominantly during the end of the nineteenth century and the beginning of the twentieth century, it is difficult to interpret long-run trends.[64] Second, as the Midelfart-Knarvik et al. (2000; 2002a; 2002b) model is demanding in terms of data, the aforementioned studies explored the determinants of industry on a single spatial level, predominantly the NUTS1 or NUTS2 level. Nevertheless, as we can imagine inter-country differences in the determinants of industrial location, we can likewise hypothesize that different determinants may dominate on different scales of spatial aggregation or that different determinants might present intra-country differences.

With our evidence, we set out to contribute to the literature in three respects. First, we use a homogeneous dataset for the Netherlands and Belgium at a detailed geographical level,

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[63] The relative short period under study in the publication of Nikolic (2018), i.e. the 1929-1939 period, does not permit any conclusions about the effect of NEG factors over time.

[64] Four studies studied the determinants of industrial location during the 1870s-1930s (Crafts and Mulatu 2005; Wolf 2007; Klein and Crafts 2012; Missiaia 2019), two studies on the 1920s-1930s (Wolf 2007; Nikolic 2018). Two studies so far studied the determinants of industry on relative longer periods of time: the 1890s-1960s (Ronsse and Rayp 2016) and the 1850s-1930s (Martinez-Galarraga 2012).

i.e. the LAU2 or municipal level. As a result, we can test for the determinants of industrial location for our two countries under study on two geographical levels, the country level and the NUTS1 level. Given the non-uniform findings in the aforementioned studies, by testing for both intra-country and inter-country differences in the determinants for the location of industry, we can introduce a natural experiment to assess the role of Heckscher-Ohlin and New Economic Geography factors. Second, we test the determinants of industry for the years of 1890, 1930, and 1970, therefore making it possible to test the relative weight of Heckscher-Ohlin and New Economic Geography factors on the *longue durée*. Third, to obtain more accurate estimates, in view of some of the methodological limitations raised in the studies until present (Rayp and Ronsse 2019), we consider in the estimation of the model econometric alternatives to measurement errors and reverse causality, while using a new proxy to market potential (in particular, the income base of real estate and land taxation).

The remainder of the chapter is structured as follows. In Section 2, we present the model and the methodological issues related to our estimates. In Section 3, we present the data and used sources. In Section 4, we present our results on the country level and the NUTS1 level. We conclude in Section 5.

5.2. Midelfarth-Knarvik model: an updated empirical framework

Historically, two major models tried to explain the determinants of industrial locations. The neoclassical Heckscher-Ohlin theorem highlights the importance of natural endowments, while the New Economic Geography theorem focuses on agglomeration effects. As both theories are not mutually exclusive, researchers have tried to estimate the relative importance of both theories, for which Kim (1995; 1998) paved the way and Davis and Weinstein (1999; 2003) soon followed. Nonetheless, it was the model of Midelfart-Knarvik et. al (2000; 2002a; 2002b) that became a mile stone in the field. Midelfart-Knarvik et. al (2000) introduced a model which integrated the two main mechanisms of location – the Heckscher-Ohlin determinants (with exogenous differences in spatial endowments) and the New Economic Geography determinants (with the size of economic activity, as well as upstream and downstream linkages between industries) – in such a way that the relative impact of both categories of determinants could be estimated. The repeated usage of the Midelfart-Knarvik et al. (2000) framework by economic historians in country-specific studies of location and distribution of industrial activity (Crafts and Mulatu 2005; Wolf 2007; Martinez-Galarraga 2012; Klein and Crafts 2012; Ronsse and Rayp 2016; Nikolic 2018; Missiaia 2019) has in this way created the standard in the field. Thus, the use of this common framework would not only allow to evaluate the relative impact of the two categories of determinants of industrial location, but also allow to compare this impact across countries and over time.

The Midelfart-Knarvik et. al (2000) model assumes perfect competition and constant returns to scale production. Preferences are characterized by love-of-variety, represented by a constant elasticity of substitution utility function (hence, product differentiation) and each industry produces an exogenously fixed number of varieties. Goods are assumed to be mobile between regions, but subject to an industry-specific and region-specific iceberg type transportation cost. From these assumptions, it follows that the value of production in each industry and region is determined by factor supply prices, intermediate goods prices and the geographical distribution of demand. The number of varieties a region can produce in an industry is assumed to be proportional to the size of the region and the industry, more specifically the region's and industry's share in total production. For the empirical model, the value of production in region and industry (as the industry-region production share) is twice normalized by the region's and industry's share in total production.

By assuming that the input factor prices depend on endowments, the model captures the Heckscher-Ohlin determinants of location. The presence of transportation costs (and an exogenous assumed number of varieties) implies that geography and location of demand are included as determinants of regional industrial activity as well. The market potential of a location, as an indicator of the *accessibility* to national and foreign markets will therefore matter for the spatial distribution of economic activity. The market potential of a location consists of two components: final goods demand and intermediate goods demand by other producers. The latter constitute the forward linkages, or downstream demand of the goods a firm produces, between industries. Finally, given that in production intermediate goods are used as an input and constitute an argument of the unit cost function, backward linkages between industries are included as determinant of location as well. In locations with a higher market potential, firms are able to buy more intermediate goods at lower transportation costs.

Linearizing production around a reference level in unit costs and market potential, results in the following empirical model, for industry *k* in region *i*:

$$ln(r_i^k) = \sum_j \beta\,[j](x_i[j] - \bar{x}[j])(y^k[j] - \bar{y}[j]) + \varepsilon_i^k \qquad \textbf{(14)}$$

where r_i^k represents the twice normalized output share of industry k in region i, i.e. the output share of industry k in region i (z_i^k) divided by the share of region i in total production ($\sum_k z_i^k$) and the share of industry k in total production ($\sum_i z_i^k$). $x_i[j]$ and $y^k[j]$ denote respectively the j^{th} characteristic of region i and industry k and $\bar{x}[j]$ ($\bar{y}[j]$) the region (industry) reference level (of the j^{th} characteristic). In other words, the Midelfart-Knarvik et. al (2000) model explains the region-specific size of an industry by the correlation of industry and region characteristics, e.g. between the region's endowment of skilled labour and the industry's demand for skilled workers. Working out the left-hand side gives:

$$ln(r_i^k) = \xi + \sum_j \{\beta[j]x_i[j]y^k[j] - \beta[j]\bar{x}[j]y^k[j] - \beta[j]\bar{y}[j]x_i[j]\} + \varepsilon_i^k \quad \textbf{(15)}$$

From this specification, it is clear that the impact of the correlation of region and industry characteristics on the size of the industry in the region are immediately identified by the parameter estimations ($\hat{\beta}[j]$) of the interaction term of industrial and regional characteristics ($x_i[j]y^k[j]$). The importance of the interaction effect is the main focus in estimating the model. The industry characteristics ($y^k[j]$) and region characteristics ($x_i[j]$) must be included to estimate the level of the interaction effects (and give, together with the parameter estimate of the interaction effect, an estimate of the region and industry reference level, $\bar{x}[j]$ and $\bar{y}[j]$ respectively). $\xi = \sum_j \beta[j]\bar{x}[j]\,\bar{y}[j]$ does not vary with i or k and therefore represents the constant of the model.

Table 28. Industry and region characteristics of the used Midelfart-Knarvik et. al (2000) model

Regional characteristics	Industry characteristics
Agricultural surface	Agricultural input
Mines	Mining input
Active population	Labour intensity
Skilled population	Skill intensity
Market potential	Use of intermediate goods, % of output
	Sales to industry, % of output
	Size

Table 29. Interactions between industrial and regional characteristics of the used Midelfart-Knarvik et. al (2000) model

Heckscher-Ohlin determinants	New Economic Geography determinants
Agricultural surface x Agricultural input	Market potential x Intermediate goods
Mines x Input of mines	Market potential x Sales to industry
Active population x Labour intensity	Market potential x Size
Educated population x skill intensity	

Table 28 gives an overview of the included region and industry characteristics. For a detailed description of these variables and their sources, we refer to section 3. Table 29 gives an overview of the interactions between the regional and industrial characteristics. Intuitively, the model combines these characteristics the following: the coefficients of the interactions reveal significant results when industries with a high level of a given industry characteristic are present in regions with a high endowment of a given region characteristic.

In the first column of Table 29, we included the neoclassical or Heckscher-Ohlin interactions. By regressing these, we analyse if industries demand a certain amount of agricultural, mines, labour or white collar inputs and are settling in regions that are rich in these respective natural endowments. We check this by interacting the amount of an endowment in a region with the demand for that endowment in an industry branch. The New Economic Geography-interactions can be found in the second column of Table 29. An important assumption of New Economic Geography studies is that industries tend to locate near industrial clusters. It is in these agglomerations that it is possible to benefit from scale effects. For instance, the interaction *market potential x size* controls for a mechanism suggested by Krugman (1991), in which it is theorized that industries with higher returns of scale tend to locate near consumption potential and near easy market access. The other interactions hold that industries that use intermediate goods very intensively or that sell a lot to other industries tend to locate in agglomerations, so transport costs will be minimized.

5.3. Panel dataset for twentieth century municipalities in Belgium and the Netherlands

As the model is demanding in terms of data, we have subdivided this section in four subsections: employment numbers (our dependent variable), regional characteristics, estimates of market potential, and industry characteristics. Data was collected on three benchmark years, roughly following 1890, 1930, and 1970. Industrial characteristics were assembled for seven different manufacturing sectors, following roughly the sectoral subdivision of the used input-output tables. Regional characteristics were collected on the LAU2 or municipal level, and afterwards collapsed to the NUTS3 level. The number of municipalities changed considerably for both countries during the nineteenth and twentieth century. In the Netherlands, the number of municipalities reduced gradually during the past two centuries, from 1.236 in 1817 to 431 municipalities in 2010, with most mergers taking place during the second half of the twentieth century (Van der Meer and Boonstra 2011). Conversely, in Belgium 2.499 municipalities in 1830 were reduced to 2.585 municipalities in 1970. After a series of large municipal reforms during the 1960s-1970s, only 589 municipalities remained in 1983 (De Belder, Vanhaute and Vrielinck 1992), a number that remained constant until 2010. As a collapse to the present-day municipalities would inhibit a bias towards agglomeration effects, we use the number of municipalities for each benchmark year as the basis for our estimates, providing us a changing number of observations for our results on the LAU2 level.

5.3.1. Employment numbers

As data on value added on a deepened disaggregated geographical level are non-existent for both countries, we turn to employment numbers as our dependent variable, which were recorded in the richly-documented industry censuses. For Belgium, we turn to the industrial census of 1896, 1937, and 1970. For the Netherlands, we turn to the recently-digitized collection of local municipal reports in 1896 (Philips 2019) and the census of companies of 1930 and 1978. As classification systems differ over these sources, we attributed each census sector to the most-fitting four-digit sector in the ISIC (*International Standard Industrial Classification of All Economic Activities*) Revision 4 classification, which we collapsed to the seven different sector aggregates for which industry characteristics were available.

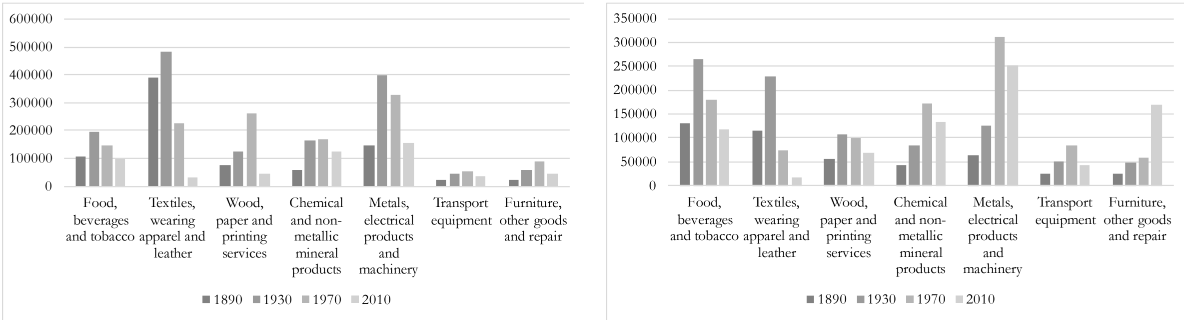
In Figure 24, we report the relative employment numbers in all industry sectors on the LAU2 level for both countries. In Belgium, we find in 1896 two centres of industry: in the north-western region where Flanders held employment in textiles was widespread, and the southern Walloon where heavy machinery and metallurgy clustered near the coal belt between Liège and Mons. The ability to attract new industries and multinational companies in Brussels and Antwerp stimulated the rise of industries in the north-eastern part of Flanders (Buyst 2018), whereas the relocation and automation of many industries introduced a relative standstill for the southern Walloon region. In the Netherlands, the western regions encompassed the industrial heartland during the studied period in absolute numbers, confirming the *Randstad* as the most urbanised and prosperous part of the country since early modern times (Van Zanden and Van Leeuwen 2012). In relative numbers, we find a relocation of industry across the more peripheral regions. In 1896 and 1930, we find notable employment in the eastern regions, where notable factories in textiles and apparel products arose, and the southern regions, where food and shoe production arose, whereas the northern regions benefitted only little from industrialization (Atzema and Wever 1994). By 1970, we find largest employment numbers in the western regions, with large companies preferring relative good access to international markets via the harbours of Amsterdam and Rotterdam, and the southern regions, where a cluster of new industries set up location around the cities of Eindhoven and Breda.

Figure 24. Relative employment numbers in all industry sectors (as a percentage of the total labour force) across LAU2 units

1890 **1930** **1970**

Figure 25 reveals a sectoral breakdown of the employment numbers for both countries. With its large coal reserves and its large pre-industrial employment in industry, Belgium held a comparative advantage in sectors which benefitted from mechanization during the first phase of industrialization (e.g. Mokyr 1976), e.g. textiles and metal production. In the Netherlands, foodstuffs and apparel production represented the largest industry sectors in 1890 and 1930, though in smaller numbers compared to its southern neighbour. The Netherlands expanded rapidly its industry base during the Interbellum and the 1950-1960s (e.g. Atzema and Wever 1994; De Jong 1999), in particular in the production of metal, chemical and other products. After 1970, automation and relocation led to a decrease in absolute employment numbers in both countries, affecting most prominently the production of textiles, metallurgy, and heavy machinery.

Figure 25. Absolute employment numbers across industry sectors



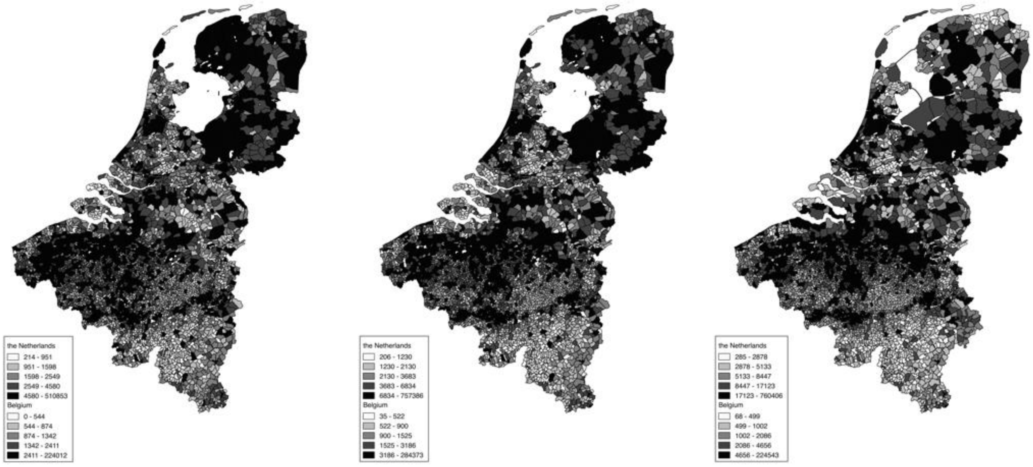
Belgium **the Netherlands**

5.3.2. Region characteristics

For region characteristics, as outlined in section 2, we collected five groups of data: population, agricultural inputs, inputs of natural resources, educated population, and market potential. Due to the extensive method to calculate market potential, this last regional characteristic was reported separately in the subsequent section.

First, due to the variation in the definition of non-active population and service-related occupations across population censuses, we proxied active population by absolute population numbers. For Belgium, statistics were retrieved from the population censuses of 1890, 1930, and 1970. For the Netherlands, these numbers are obtained from the 1899, 1930, and 1971 population censuses, digitized by the HED or *Historical-Ecological Database* (Beekink et al. 2003). We report these numbers in Figure 26. Population clustered in Belgium around the agglomerations of Brussels, Antwerp, Ghent, and their direct vicinities. Similarly, in the Netherlands, most populous regions are found in the west, encapsulating the metropolitan areas of Amsterdam, Rotterdam, The Hague, and Utrecht.

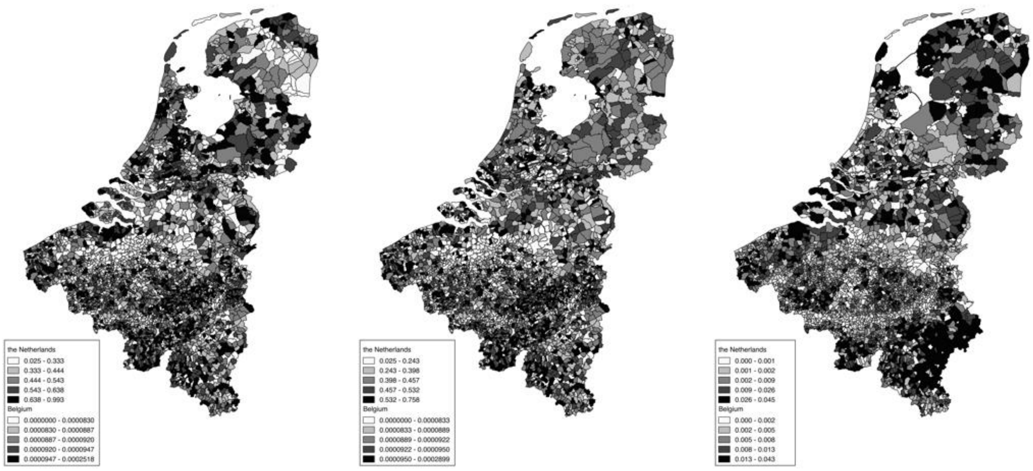
Figure 26. Population across LAU2 units



1890 **1930** **1970**

Second, agricultural inputs. For Belgium in 1890 and 1930, we used the arable acreage and livestock as recorded in the agricultural censuses of respectively 1895 and 1910. For 1970, we use employment numbers in agriculture, retrieved from the 1970 population census. Data on arable acreage in the Netherlands are not documented on the LAU2 level, in agricultural nor population censuses, Therefore, we turned to employment numbers in agriculture, as recorded in the population census of 1899, 1930, and 1971. Turning to Figure 27, we notice that the location of agricultural inputs remained fairly constant over time. In Belgium, clustering around the regions of Haspengouw, the Ardennes, and West-Flanders. In the Netherlands, in the Dutch north and the southern and eastern rural areas.

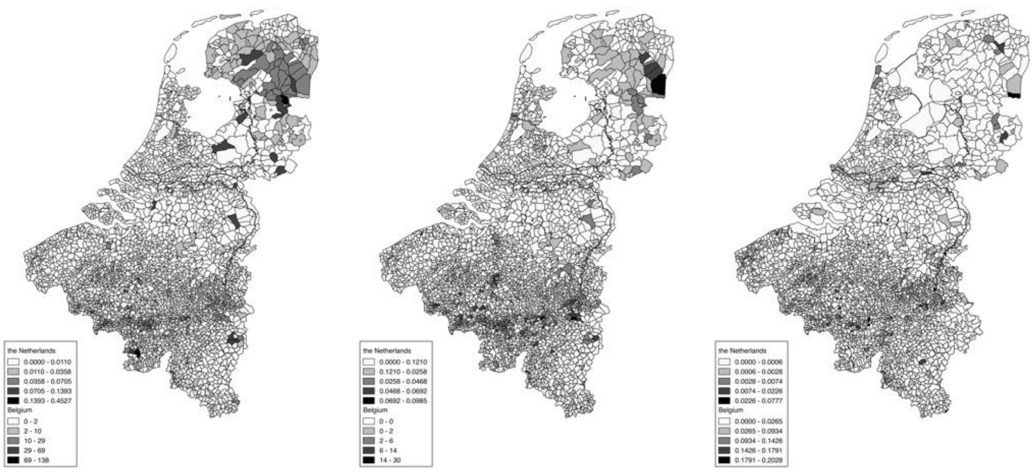
Figure 27. Agricultural inputs across LAU2 units



1890 **1930** **1970**

Third, inputs of natural resources. For Belgium in 1890 and 1930, we collected the number of mining extraction sites, encompassing all types of mining and quarrying activities, as reported in the censuses of industry of 1896 and 1937. For 1970 in Belgium, we turned to the employment in mining and quarrying as reported in the 1970 census of industry. For the Netherlands, we used the number of employees in mining and quarrying, as reported in the aforementioned industry censuses of 1896, 1930 and 1978. Figure 28 shows that mining and quarrying activities in the Netherlands were grossly confined to the northern and eastern regions, where depletion sites of minerals could be found, in particular peat extraction in 1890 and 1930. In Belgium, the extraction of coal and metal ores was widespread alongside the Meuse-Sambre rivers, whereas quarrying activities were more dispersedly located throughout the Belgian south. In addition, in smaller amount, coal extraction took place during the 1900-1960s in Dutch and Belgian Limburg.

Figure 28. Inputs of natural resources across LAU2 units



1890 **1930** **1970**

Fourth, human capital: for 1890 and 1930 we turn to literacy rates as a proxy, whereas we used the population with a bachelor, master, or equivalent degree for 1970. For Belgium, this was reported in the population censuses of 1890, 1930, 1970. For the Netherlands, we calculated the average literacy per municipality in 1890 and 1930 by using the HSN (*Historical Sample of the Netherlands*) dataset.[65] For 1970, we turned to the statistics collected by the

[65] The HSN dataset provided a vast database of marriage contracts for the 1850 – 1950 period. We used the ratio of these marriage contracts signed by the grooms and brides, subdivided in the municipality where the marriage took place, as an indicator of literacy rates per municipality.

CBS.[66] Turning to Figure 29, we find that in 1890 the northern Flemish regions in Belgium and the eastern and northern Dutch regions faced a relative low human capital endowments, although the democratization of schooling removed many of these regional differences by 1930. In 1970, we find that urban centres house the majority of the educated population, benefitting disproportionally the western Holland, Flevoland and Utrecht regions in the Netherlands. Similarly, in Belgium, the Brussels-capital region as well as the agglomerations around the cities of Antwerp, Ghent and Liège present the highest human capital rates for 1970.

Figure 29. Human capital levels across LAU2 units

1890 **1930** **1970**

5.3.3. Estimates of market potential

Market potential is calculated according to the approach first proposed by Harris (1954) as:

$$MP_i = \sum_j \left({M_j}/{D_{ij}} \right) \qquad \textbf{(16)}$$

in which the sum of the size (*M*) of the home and neighbouring regions, weighted by the distance (*D*) to the home region *i*, where the size of region is in general defined in terms of Gross Domestic Product (GDP). For the neighbouring regions, market potential has a domestic as well as a foreign component (the region's export potential). Thus, market potential compromises three components: the size of the home region, the size of the domestic

[66] CBS, Statistics Netherlands (2010). *Regionale kerncijfers Nederland / Regional highlights Netherlands*. https://opendata.cbs.nl/statline/#/CBS/nl/dataset/82801NED/table?ts=1554214212600 (accessed on 23/11/2018).

neighbouring regions and the size of the foreign neighbouring regions (as the region's export potential). The size of a region is in most studies defined in terms of gross domestic product and the size of foreign neighbouring regions as the distance-weighted sum of the gross domestic product of the country's main export markets. Given the difficulties to reconstruct gross domestic product data at the regional level, the aforementioned economic history studies that used the Midelfart-Knarvik et. al (2000) model have predominantly used the Geary and Stark (2002) approximation of reconstructing regional gross domestic product. In this setting, gross domestic product of region *i* is defined as:

$$Y_i = \sum_k y_{ik} L_{ik} \qquad \textbf{(17)}$$

where y_{ik} is the average output per worker in industry k and region i and L_{ik} employment in industry *k* and region *i*. While historical data of employment are frequently available, this is more problematic for average output per worker or y_{ik}. Here, it is assumed that the national average of output per worker in industry k as y_k and that the regional to national average output per worker in industry *k* is proportional with the regional to the nation-wide wage in industry k or $\frac{y_{ik}}{y_k}=\beta_k \frac{w_{ik}}{w_k}$.[67] Working out the equation,[68] regional gross domestic product in region *i* is described as:

$$Y_i = \sum_k \beta_k y_k \frac{w_{ik}}{w_k} L_{ik} \qquad \textbf{(18)}$$

Following Crafts and Mulatu (2005), most aforementioned economic historical studies have used the Geary-Stark (2002) approximation of calculating historical regional gross domestic product levels (Wolf 2007; Klein and Crafts 2012; Ronsse and Rayp 2016; Nikolic 2018; Missiaia 2019). However, at the deepened level of geographical detail that we consider in our study, regional wage data are unavailable, which implies that this method could not be followed. As an alternative, we used tax revenues from the income base of real estate and land, which were similarly used in the study of Martinez-Galarraga (2012) to proxy regional GDP levels. Next, we use these tax statistics, which were documented on the local LAU2 level, to

[67] The factor of proportion is such that the GDP of industry k at the country level (Y_k) equals the sum of the regional estimations, i.e. $\beta_k = \frac{Y_k}{\sum_i y_k \frac{w_{ik}}{w_k} L_{ik}}$.

[68] Inserting the expression for β_k and working out the expression gives $Y_i = \sum_k Y_k \frac{w_{ik} L_{ik}}{\sum_i w_{ik} L_{ik_k}}$, i.e. regional GDP as the sum over all industries of industry GDP at the national level, broken down by the regional share in the total wage sum.

break down national gross domestic product levels. For the national gross domestic product levels, we used the *Penn World Tables*.[69] For the statistics on tax revenues in Belgium, we used the taxable income base of real estate and land taxation for 1890 and 1930, as reported in the censuses of population. For 1970, we used the taxable income base on land and buildings as reported in the 1970 population census. For the Netherlands in 1890, we used the revenues from the land and personal tax, digitized by the aforementioned HDNG/HED database. For 1930, we used the revenue from income taxes as reported in the *Handbook for Market Research in the Netherlands* of 1935. As the Dutch statistical office did not document statistics on taxable revenues on regional levels prior to the *Valuation of Immovable Property Act* of 1994, we used the average housing value multiplied with the number of houses in 1994 as a proxy for 1970.[70]

Using these estimates of local gross domestic product, we proceeded following the Harris (1954) approach to calculate domestic market potential as the distance discounted sum of local gross domestic product.[71] Export market potential, as the second component of aggregate market potential varies between localities based on their distance to the borders, weighted with the share of the bordering country as well as the share of terrestrial transport in total exports, and the distance to the main ports of the countries, weighted with the share of shipping in total exports.

In Figure 30, we reported our estimates of market potential. In 1890, we find the largest values of market potential near international trade hubs. In Belgium, we find these international trade hubs alongside the coast, the port of Antwerp, and Liège. In the Netherlands, we find these centres alongside the ports of Amsterdam, Rotterdam, Groningen, and the cities with relatively good access to the Rhine river and the German market. By 1930, market potential in the Dutch western and central regions has risen, due to increasing trade in the ports of Amsterdam and Rotterdam, at the expense of the peripheral eastern and northern regions. Likewise, market potential in Belgium shifted to the commercial centres of Antwerp, Brussels, and Liège, whereas the more inland areas experienced a relative standstill. During 1930-1970, we find a continuation of these patterns, with mostly the central-located urban centres in both

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[69] See https://www.rug.nl/ggdc/productivity/pwt/

[70] Obtained from the Dutch Statistical Office or CBS, Statistics Netherlands (2010). *Regionale kerncijfers Nederland / Regional highlights Netherlands*. (accessed on 23/11/2018), online accessible via https://opendata.cbs.nl/statline/#/CBS/nl/dataset/82801NED/table?ts=1554214212600

[71] Because we aggregate from the GDP at LAU2 level, we did not correct for the distance within a locality, which was set equal to 1.

countries benefiting from this evolution. In the Netherlands, this was the case for Rotterdam, Amsterdam, and – to a lesser degree – the populous cities in the Dutch south. In Belgium, Antwerp and Ghent rose, including the cities of Liège and Kortrijk with access to respectively the German and French markets.

Figure 30. Market potential across LAU2 units

1890 **1930** **1970**

5.3.4. Industry characteristics

We used two sets of sources for the industry characteristics. On the one hand, the input-output table of the Netherlands in 1913 as constructed by Notten, Smits and Hoekstra (2015) and the input-output table of 1970 as constructed by the Dutch Statistical Office,[72] for the characteristics on imports, exports, agricultural inputs, mining inputs, and the use of intermediate goods. On the other hand, we turned for the characteristics on capital intensity, size, and human capital intensity to a multitude of sources. For capital intensity in 1896 and 1937, we used the amount of used horse power by steam engines as reported in the industry censuses of Belgium of 1896 and 1937. For 1970, we turned to the capital stock numbers in Belgium from OESO Statistics. For size, we turned to the average size of establishments as reported in the industry censuses of Belgium of 1896, 1937 and 1970. For human capital intensity, we used the ratio between blue and white collar workers, as reported in the Belgian

[72] http://www.cbs.nl/nl-NL/menu/themas/macro-economie/cijfers/incidenteel/maatwerk/2012-i-o-cm.htm

industry censuses of 1896, and 1937. For 1970, we turned to the 1970 edition of the *Statistiques Industrielles*.[73] The industry characteristics are reported in Table 30.

Table 30. Industry characteristics, across sectors, for 1890-1970

	agricultural input			mining input			use of intermediate goods (% of output)		
	1890	1930	1970	1890	1930	1970	1890	1930	1970
Food, beverages and tobacco	0,212	0,212	0,061	0,001	0,001	0,006	0,159	0,159	0,208
Textiles, wearing apparel and leather	0,023	0,023	0,004	0,001	0,001	0,002	0,162	0,162	0,278
Wood, paper and printing services	0,009	0,009	0,001	0,002	0,002	0,015	0,098	0,098	0,392
Chemical and non-metallic products	0,013	0,013	0,002	0,043	0,043	0,033	0,063	0,063	0,388
Metals, electrical products, machinery	0,001	0,001	0,001	0,001	0,001	0,004	0,188	0,188	0,397
Transport equipment	0,003	0,003	0,001	0,001	0,001	0,001	0,119	0,119	0,439
Furniture, other goods and repair	0,004	0,004	0,001	0,020	0,020	0,001	0,037	0,037	0,468
	imports			sales to industry (% of output)			exports		
	1890	1930	1970	1890	1930	1970	1890	1930	1970
Food, beverages and tobacco	0,174	0,174	0,488	0,292	0,292	0,103	0,209	0,209	0,316
Textiles, wearing apparel and leather	0,148	0,148	0,367	0,175	0,175	0,056	0,316	0,316	0,383
Wood, paper and printing services	0,237	0,237	0,115	0,488	0,488	0,155	0,357	0,357	0,179
Chemical and non-metallic products	0,468	0,468	0,199	0,513	0,513	0,321	0,252	0,252	0,407
Metals, electrical products, machinery	0,180	0,180	0,146	0,315	0,315	0,358	0,242	0,242	0,343
Transport equipment	0,155	0,155	0,184	0,452	0,452	0,055	0,076	0,076	0,347
Furniture, other goods and repair	0,501	0,501	0,066	0,078	0,078	0,062	0,287	0,287	0,142
	capital intensity			size			skill intensity (% of labour force)		
	1890	1930	1970	1890	1930	1970	1890	1930	1970
Food, beverages and tobacco	0,419	1,882	69,716	5,634	8,885	19,428	0,424	0,133	0,340
Textiles, wearing apparel and leather	0,181	1,107	29,158	5,341	5,565	14,558	1,197	0,080	0,118
Wood, paper and printing services	0,166	3,270	57,309	5,249	13,770	20,409	0,604	0,094	0,152
Chemical and non-metallic products	0,304	3,350	68,958	23,023	33,122	37,819	0,110	0,160	0,351
Metals, electrical products, machinery	0,111	3,187	56,736	6,732	12,857	50,446	0,241	0,133	0,282
Transport equipment	0,103	3,084	38,812	11,075	16,315	41,692	0,414	0,116	0,231
Furniture, other goods and repair	0,019	0,952	57,272	5,100	6,281	12,457	0,403	0,056	0,103

5.4. Results on the Midelfart-Knarvik model for the Low Countries

5.4.1. Midelfart-Knarvik estimates for Belgium

The results for Belgium are reported in Tables 31-33, for the benchmark years of respectively 1896, 1937, and 1970, for both Belgium as well as the three NUTS1 levels in Belgium. First, the results for Belgium. Our results indicate for both Heckscher-Ohlin and New Economic Geography factors significant and positive results. The significant New Economic Geography factors are size of industry for 1896 and 1937, while in 1970 both use of intermediate goods and sales to industry yield significant coefficients. Likewise, we find a shift in the significant Heckscher-Ohlin factors: we find significant effects for agricultural inputs, mining inputs, and labor intensity in 1896 and 1937, whereas in 1970 labor intensity and human capital intensity

[73] Statistiques Industrielles (1970). Institut national de statistique, ministère des affaires economiques.

become significant. All in all, New Economic Geography determinants explain approximately 20 % of the variation in the location of industry in Belgium during 1896-1970, whereas Heckscher-Ohlin factors account for approximately 40 %.

Yet, turning to the results on NUTS1 levels, we find evidence for significant regional disparities within Belgium. For Flanders, we find a shift from Heckscher-Ohlin determinants in 1896 and 1937, with significant coefficients for agricultural inputs in 1896 and labor in 1937, to both Heckscher-Ohlin determinants (human capital inputs) and New Economic Geography determinants (sales to industry and use of intermediate goods) in 1970. For Wallonia, we find a shift from both New Economic Geography determinants (sales to industry) and Heckscher-Ohlin determinants (capital intensity and agricultural inputs) in 1896 to only Heckscher-Ohlin determinants (labor intensity) in 1970. All in all, we find a higher explanatory factor of New Economic Geography determinants in Flanders, explained by the better access to domestic markets – as Flanders is the most populous part of the country – and international markets – with the port of Antwerp as the main trading hub for the country. As such, we find evidence that the lack of substantial market access for Wallonia compared to Flanders was responsible for the disproportionate relocation and disappearance of industrial activities during the second half of the twentieth century in Wallonia.

Table 31. Estimates of the Midelfart-Knarvik model for Belgium in 1896

	(1) country Belgium OLS	(2) country Belgium IV (lag)	(3) nuts1 Flanders OLS	(4) nuts1 Flanders IV (lag)	(5) nuts1 Brabant OLS	(6) nuts1 Brabant IV (lag)	(7) nuts1 Wallonia OLS	(8) nuts1 Wallonia IV (lag)
Employment in ind. (lag)		0.735***		0.650***		0.737***		0.837***
HO determinants								
Agricultural inputs	0.0005***	-2.73e-06	0.0009***	0.0002***	0.0004	-0.0002	-0.0002	-0.0002**
Skill intensity	-3.26e-06	2.10e-06	-6.66e-06	2.26e-06	3.95e-06	8e-06***	1.56e-05	-4.24e-07
Mining inputs	0.218***	0.0230**					0.160***	0.0078
Labor intensity	-8.91e-06	1.17e-06	-9.70e-06	-7.70e-07	6.81e-07	5e-06**	1.21e-05	2.29e-06
NEG determinants								
Use of intermediate goods	-0.004	0.0110**	-0.00288	0.00586	-0.419***	0.0317	0.0211	0.0017
Sales to industry	0.025**	-0.0005	0.0101	0.00150	0.153	-0.139*	0.0459**	-0.0147**
Size of industry	-9.68e-05	4e-05**	8.25e-05	4.59e-05	0.0003	0.002***	0.0002	-4.68e-05
Observations	13,228	8,175	4,723	3,100	1,781	1,110	6,724	3,965
R-squared	0.158	0.875	0.303	0.886	0.238	0.886	0.118	0.908

Table 32. Estimates of the Midelfart-Knarvik model for Belgium in 1937

	(1) country Belgium OLS	(2) country Belgium IV (lag)	(3) nuts1 Flanders OLS	(4) nuts1 Flanders IV (lag)	(5) nuts1 Brabant OLS	(6) nuts1 Brabant IV (lag)	(7) nuts1 Wallonia OLS	(8) nuts1 Wallonia IV (lag)
Employment in ind. (lag)		0.574***		0.459***		0.559***		0.633***

HO determinants								
Agricultural inputs	0.0006***	0.0003*	0.0007***	0.0003	0.0007	0.0004	0.0001	0.0004
Skill intensity	0.151*	0.105	0.172	0.172	-0.130	-0.352	-0.15	-0.03
Mining inputs	-0.01	-0.01	0.09	0.141**			-0.03	-0.03
Labor intensity	-2e-06***	-2e-06***	-1.93e-06*	-1e-06*	-1e-06**	-1e-06*	-4.16e-06	-3.49e-06
NEG determinants								
Use of intermediate goods	-0.008***	-0.003	-0.01***	-0.008**	0.03	0.07	0.04	0.03
Sales to industry	0.002	0.0005	0.005**	0.005*	-0.02	0.007	-0.01	-0.03
Size of industry	-1.97e-06	2e-05***	1.10e-05	1.58e-05	-0.0002	-0.0003	0.0002*	0.0001
Observations	7,075	6,352	3,027	2,694	1,024	900	3,024	2,758
R-squared	0.130	0.272	0.175	0.258	0.151	0.279	0.155	0.331

Table 33. Estimates of the Midelfart-Knarvik model for Belgium in 1970

	(1) country Belgium OLS	(2) country Belgium IV (lag)	(3) nuts1 Flanders OLS	(4) nuts1 Flanders IV (lag)	(5) nuts1 Brabant OLS	(6) nuts1 Brabant IV (lag)	(7) nuts1 Wallonia OLS	(8) nuts1 Wallonia IV (lag)
		0.464***		0.426***				
Employment in ind. (lag)						0.406***		0.472***
HO determinants								
Agricultural inputs	0.002**	-0.001	0.00408***	0.001	0.0006	-0.004	0.001	-0.002
Skill intensity	0.001**	0.001***	0.001**	0.001***	0.0007***	0.0005**	0.0005	0.0001
Mining inputs	1e-06	2.34e-06*	4.e-06***	2.93e-06	1.45e-06	1.76e-06	-3.83e-07	3.07e-06
Labor intensity	-4e-07***	-2e-07***	-2.18e-07	-1.78e-07	-5e-07***	-4e-07***	-5e-07**	-3e-07**
NEG determinants								
Use of intermediate goods	0.001	0.003**	0.005**	0.006***	-0.094**	-0.003	-0.002	0.0005
Sales to industry	-0.0005	0.0003	0.002	0.003*	-0.01	0.01	-0.001	-0.0004
Size of industry	-5.02e-07	-7.69e-06	1.63e-05	-1.00e-05	0.000504*	0.000325	4.59e-06	-1.69e-06
Observations	8,315	5,423	3,389	2,375	1,338	875	3,588	2,173
R-squared	0.093	0.315	0.128	0.310	0.150	0.335	0.138	0.358

5.4.2. Midelfart-Knarvik estimates for the Netherlands

The results for the Netherlands are reported in Tables 34-36, for the benchmark years of respectively 1896, 1930, and 1970, for both the Netherlands as well as the four NUTS1 levels. First, the results for the Netherlands as reported in Columns 1-2. Our results indicate for both Heckscher-Ohlin and New Economic Geography factors significant and positive results. The significant New Economic Geography factors are size of industry for 1896 and 1937 and use of intermediate goods in 1937, while in 1970 sales to industry yield significant coefficients. Likewise, we find a shift in the Heckscher-Ohlin factors: we find significant effects for agricultural inputs, mining inputs, skill intensity, and labor intensity in 1896 and 1937, whereas in 1970 agricultural inputs become significant. All in all, New Economic Geography determinants explain approximately 25 % of the variation in the location of industry in Belgium during 1896-1970, whereas Heckscher-Ohlin factors account for approximately 60 %. Compared to the results for Belgium in Tables 31-33, we find for the Netherlands a relatively higher explanatory factor for agricultural inputs, plausibly due to the prominence of food production in the Dutch industry mix.

Turning to the results on NUTS1 levels, we find evidence for significant regional disparities within the Netherlands, most specifically between the Western NUTS1 level and the other NUTS1 levels in the country. This is no surprise, as the Western region in the Netherlands encompasses the demographic forerunner of the country, encompassing the cities of Amsterdam, Rotterdam, Utrecht, and The Hague, while these regions are widely considered the economic heart of the country compared to the rather 'peripheral' eastern, northern, and southern regions in the country. For the Western region of the country, we find significant results for both New Economic Geography (in 1896 the size of industry, in 1930 and 1970 the use of intermediate goods) and Heckscher-Ohlin determinants (in 1896 agricultural inputs and skill intensity, in 1930 skill intensity). Compared to the Western regions, we find for the eastern, northern, and southern regions exclusively significant results for Heckscher-Ohlin determinants. For the northern regions, we find a significant effect of agricultural inputs and labor intensity for 1896, and labor intensity and skill intensity for 1930. For the eastern regions, we find a significant effect of labor intensity and agricultural inputs and labor intensity for 1930 and a significant effect of agricultural inputs for 1970.

Table 34. Estimates of the Midelfart-Knarvik model for the Netherlands in 1896

	(1) country Netherl. OLS	(2) country Netherl. IV (lag)	(3) nuts1 North Nl. OLS	(4) nuts1 North Nl. IV (lag)	(5) nuts1 East Nl. OLS	(6) nuts1 East Nl. IV (lag)	(7) nuts1 West Nl. OLS	(8) nuts1 West Nl. IV (lag)	(9) nuts1 South Nl. OLS	(10) nuts1 South Nl. IV (lag)
		0.703***		0.547***						
Employment in ind. (lag)						0.744***		0.743***		0.791***
HO determinants										
Agricultural inputs	8e-05***	5e-05***	0.000525**	0.000539***	0.000817***	6.71e-05	8e-05***	3.21e-05**	0.000122	8.90e-06
Skill intensity	-0.0281***	-0.0112***	-0.0324***	-0.0140	-0.0150	-0.00803	-0.0231**	-0.00840*	0.00230	-0.00469
Mining inputs	0.00238**	0.00187***	0.000582	0.00124	-0.00261	0.000143	0.0208***	-0.00926	0.00572	0.000613
Labor intensity	-2e-05***	-2e-05***	-0.00011**	-8.05e-05**	-0.00028***	-9.34e-06	-2e-05***	-1.12e-05**	5.40e-06	-1.83e-05
NEG determinants										
Use of intermediate goods	0.00654	-0.00947	0.0246**	0.00395	0.00616	-0.00159	0.0583**	0.0150	-0.00761	0.00423
Sales to industry	0.0183*	0.0136*	-0.0122	0.00116	0.0181	-0.00772	-0.00728	0.00186	0.0209	0.0162
Size of industry	0.000144**	0.000109**	2.99e-05	4.80e-05	0.000204	-7.36e-05	0.000392*	0.000206**	0.000129	4.97e-05
Observations	5,890	4,300	747	638	995	810	2,697	1,833	1,451	1,019
R-squared	0.045	0.625	0.163	0.560	0.143	0.674	0.104	0.722	0.187	0.765

Table 35. Estimates of the Midelfart-Knarvik model for the Netherlands in 1930

	(1) country Netherl. OLS	(2) country Netherl. IV (lag)	(3) nuts1 North Nl. OLS	(4) nuts1 North Nl. IV (lag)	(5) nuts1 East Nl. OLS	(6) nuts1 East Nl. IV (lag)	(7) nuts1 West Nl. OLS	(8) nuts1 West Nl. IV (lag)	(9) nuts1 South Nl. OLS	(10) nuts1 South Nl. IV (lag)
		0.847***		0.841***						
Employment in ind. (lag)						1.010***		0.908***		0.871***
HO determinants										
Agricultural inputs	5.89e-05	-8.72e-06	-3.70e-06	-4.25e-05	-0.0002**	-9e-05***	-1.38e-05	1.85e-05	0.000124**	-3.91e-05
Skill intensity	-0.0604	-0.165**	-0.643*	-0.630***	0.181	0.196**	-0.356*	-0.478***	0.349	-0.0372
Mining inputs	-5.37e-05	-2.32e-05	9.98e-06	3.09e-05	-0.001	-0.001	-0.003	-0.002**	0.0002	0.001
Labor intensity	-3.83e-07	-7.96e-09	-7e-06***	-7e-06***	-1e-05***	-2e-06***	-1.15e-07	1.47e-08	3.13e-06	4.77e-06**
NEG determinants										
Use of intermediate goods	0.01***	0.007**	-0.007	-0.02**	-0.02	-0.02***	0.03***	0.01**	0.01*	0.01*
Sales to industry	-0.01**	-0.01***	0.01	0.02**	0.03	0.03**	-0.02**	-0.006	-0.004	-0.004
Size of industry	-6.18e-06	-2.42e-05*	0.0001	0.0002***	0.0002	6e-05***	4.87e-05	9.30e-05**	-2.41e-05	-5e-05***
Observations	5,383	5,331	689	689	924	907	2,461	2,455	1,309	1,280
R-squared	0.076	0.681	0.238	0.758	0.209	0.900	0.068	0.757	0.108	0.667

Table 36. Estimates of the Midelfart-Knarvik model for the Netherlands in 1970

	(1) country Netherl. OLS	(2) country Netherl. IV (lag)	(3) nuts1 North Nl. OLS	(4) nuts1 North Nl. IV (lag)	(5) nuts1 East Nl. OLS	(6) nuts1 East Nl. IV (lag)	(7) nuts1 West Nl. OLS	(8) nuts1 West Nl. IV (lag)	(9) nuts1 South Nl. OLS	(10) nuts1 South Nl. IV (lag)
		0.216***		0.252***						
Employment in ind. (lag)						0.283***		0.185***		0.112**
HO determinants										
Agricultural inputs	0.0237*	0.0307**	0.0309	0.0223	0.0507**	0.0697***	-0.0236	-0.0148	0.0104	0.0150
Skill intensity	-0.000382	-0.000355	-0.000922	-0.000758	-0.00199*	-0.00143	-0.000285	-0.000550	0.000115	0.000663
Mining inputs	7.10e-06	1.34e-05	-2.57e-05	-2.48e-05	-1.02e-05	4.32e-07	3.82e-05	4.31e-05	0.000348**	9.27e-05
Labor intensity	4.75e-08	4.23e-08	3.62e-07	3.04e-07	2.13e-07	2.38e-07	1.77e-08	2.30e-08	4.81e-08	5.62e-08
NEG determinants										
Use of intermediate goods	7.50e-07	1.39e-06	-6.77e-07	-1.75e-06	9.06e-07	1.57e-06	3.25e-06**	3e-06***	1.16e-06	1.33e-07
Sales to industry	1.24e-06**	1.04e-06*	1.21e-06	8.40e-07	-2.02e-07	-5.24e-08	-3.52e-07	-6.21e-07	2.25e-06*	2.75e-06**
Size of industry	4.74e-09	4.52e-09	-3.07e-09	1.29e-09	1e-08***	9.43e-09*	6.34e-09	6.24e-09	4.09e-09	3.82e-09
Observations	4,334	3,121	601	440	846	637	1,676	1,178	1,211	866
R-squared	0.052	0.087	0.132	0.165	0.077	0.161	0.065	0.097	0.086	0.113

5.5. Conclusion: the determinants of industrial location during the twentieth century

Our results present a considerable variation in both inter-country and intra-country variation in the determinants of industrial location. Our results on the country level for the Netherlands indicate a shift towards New Economic Geography factors during 1896 – 1970, whereas agricultural inputs remain an important explanatory factor due to the prominence of food production in the Dutch industry mix. For Belgium, we notice a shift from agricultural and mining inputs for the 1890-1930 period, whereas endowment in human capital appear increasingly significant for the 1930 -1970 period. On the NUTS1 level, we find significant evidence for regional disparities in both countries. In the Netherlands, we find that both New Economic Geography and Heckscher-Ohlin determinants can explain the location of industry in the populous Western regions, due to the market access via the ports of Rotterdam and Amsterdam, whereas the more 'peripheral' eastern, northern and southern regions only Heckscher-Ohlin determinants appear significant. Similarly, we find for Belgium that for the northern region of Flanders, with access to international markets via the port of Antwerp and a larger domestic market, both Heckscher-Ohlin and New Economic Geography determinants play, whereas in the land-locked Wallonia region only Heckscher-Ohlin determinants explain the location of industry. As such, our results suggest an explanation for the relative higher disappearance of manufacturing jobs in both Wallonia and the peripheral Dutch regions after the 1960s.

Whereas the earlier economic history studies (Crafts and Mulatu 2005; Wolf 2007; Martinez-Galarraga 2012; Klein and Crafts 2012; Ronsse and Rayp 2016; Nikolic 2018; Missiaia 2019) found a relative balance in the explanatory power of Heckscher-Ohlin and New Economic Geography determinants, our results indicate a dominance of Heckscher-Ohlin factors. These findings not only nuance the explanatory power of agglomeration effects for the location of industry, as New Economic Geography factors appear only significant on higher-aggregated levels, but also rehabilitate the role of Heckscher-Ohlin determinants as the most influential explanation of why regions specialized in particular industry sectors (see e.g. Brülhart 1998). Although these results provide considerable insight into the determinants of the location of industry in Belgium and the Netherlands during 1896-1970, they are presented by unneglectable limitations to what conclusions can be drawn from this limited evidence. First, an avenue of future exploration will be to test for the determinants of industry on a longer time period for which data is available, by including the benchmark years of 1850 and 2010. Second, due to the variability in results between the country and NUTS1 levels, we have to explore further how and why the determinants might differ over different levels of spatial aggregation.

Chapter 6. The transition towards de-industrialization

(together with Péter Földvàri and Bas van Leeuwen)[74]

6.1. Introduction: resilience against de-industrialization

The Industrial Revolution is often framed by economic historians as the start of modern economic growth. Yet, when taking a look at the regions that participated early in this Industrial Revolution – the Great Lakes region in the USA, the Midlands in the UK, the Ruhr area in Germany, and the Nord-Pas-de-Calais region in France –, it seems that these regions are at present confronted with below average income levels and above average unemployment rates compared to the regions within the same country. Despite the attention that this topic has received among economists, historians and economic geographers, the question what explains the 'reversal of fortune' of these early industrialized regions remains largely unanswered. The following article contributes to this debate, by investigating the long-run economic development of municipalities in the Netherlands and Belgium that suffered from de-industrialization during 1970-2010.

Indeed, many theories have suggested that early industrialization can be beneficial to local economic development, through various channels. For instance, early industrialization is argued to have risen local living standards. In turn, this increase in income per capita may lead to population growth and migration to these industrialized regions, which give rise to agglomeration effects and subsequently local productivity growth (e.g. Meyer 1998; Combes et al. 2011).

Yet, other theories have predicted more detrimental effects, in which the literature on so-called rust belts often presented a deterministic view through which mechanisms emerge from the early industrial period that might hinder economic growth in the long-run. For

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[74] This chapter is largely based upon the following working paper: Philips, R., Földvàri, P. and Van Leeuwen, B. "Long-run origins of resilience against de-industrialization and unemployment in Belgium and the Netherlands (1970 – 2010)". Furthermore, we would like to thank the Historical Database of Local and Cadastral Statistics LOKSTAT-POPPKAD (Quetelet Center, Ghent University), specifically Sven Vrielinck, and the Historical Sample of the Netherlands (HSN), specifically Kees Mandemakers, for providing data. Additionally, we want to thank Ron Boschma, Karel Davids and Jan Luiten van Zanden for comments, as well as the participants of the 2018 workshop 'An Historical Account of Regional Resilience' in Leeuwarden, the 2019 Economic History Society Conference, the economic history seminar at Wageningen University.

instance, it has been argued that early industrial development hindered the accumulation of human capital (e.g. Glaeser 2005; Kitsos and Bishop 2016) or led to a rise of predominantly unskilled labour (e.g. Martin 2012; Diodato and Weterings 2015). For example, Franck and Galor (2017) attribute the economic decline in the Nord-Pas-de-Calais region in France to a historical lower accumulation of human capital - compared to the other French regions - since the end of the nineteenth century. Other theories argued that a lack of diversity in the economic structure made some regions less able to overcome economic hardship (Hobor 2016; Martin et al. 2016; Brown and Greenbaum 2017). One example is the study by Grabher (1993), who argued that the specialization in coal mining and steel production exposed the Ruhr area in Germany to a higher risk of economic depression when these sectors started to relocate and automate after the 1960s.

Recently, in the emerging field of evolutionary economic geography, another view on regional economic growth was formulated. Here, together with the emphasis on slow-burn processes of related and unrelated variety, or adaptation and adaptability (see e.g. Boschma 2015; Martin and Sunley 2015), special attention was paid to the concept of regional resilience, defined as ‘the capacity to withstand or recover from market, competitive and environmental shocks to its developmental growth path, if necessary by undergoing adaptive changes to its economic structures and its social and institutional arrangements’ (Martin and Sunley 2015: 13). As such, this line of research presents a less deterministic picture on regional decline. In this perspective, factors such as the existing economic structure will determine resilience, or the capabilities to absorb or overcome shocks such as de-industrialization, whereas outward signs of depravity do not manifest itself prior to such shocks.

The literature on so-called rust-belt areas often provide case-studies of local economies which heavily industrialized over the nineteenth and early twentieth century and subsequently lost a great deal of manufacturing jobs in recent decades. Existing research typically focuses on a particular present-day rust belt region. Yet, as such studies focus on a single region, they provide limited information about the question to what degree the economic performance of these rust belt regions differed from other, economically well-preforming, regions. Other studies have put a larger region under study, in which the rust belt region comprises only a part of the studied region, and in which they often identified the region with the highest loss of manufacturing jobs in a particular region as an archetypical rust belt region. Yet, even such a test case becomes problematic, once considering that some regions with a heavy decline of manufacturing jobs experienced economic growth in the last decades, and thus some de-industrialized regions were able to avoid evolving into a rust belt region.

This chapter adds to our understanding of economic development in de-industrialized regions in two ways. First, rather than following an ex-post notion of which regions compose rust belt regions, we introduce an unbiased classification strategy to identify the regions in the Netherlands and Belgium that experienced high unemployment rates at present as a result of de-industrialization during the past four decades. For instance, in Belgium, the Mons-Liège axis is considered as a region which suffered from de-industrialization (e.g. De Brabander 1983; Buyst 1997). By using an econometric method to redraw the map of rust belt regions in both countries, we can not only validate this claim, but also determine whether areas outside the archetypical rust belt area experienced similar negative effects due to de-industrialization.

Second, we study the differences between the municipalities which were resilient against de-industrialization and the non-resilient municipalities, in both the period of de-industrialization (1970-2010) as well as the period preceding the shock of de-industrialization (1850-1970), to determine to which degree the rust belt regions in recent decades actually followed a long-run transgressive trajectory of economic decline. In particular, we study the differences in economic performance between resilient and non-resilient municipalities in economic performance, but also the differences in economic structure – measured by employment shares across economic sectors, with a particular focus on the structure of the manufacturing sector.

Turning to the results, we find that for most municipalities unemployment in 2010 can be explained by the level of local economic growth in 1970. However, our switching model identifies that for one tenth of all municipalities in Belgium and the Netherlands, mostly but not exclusively located near the region that has been described as the rust belt in Belgium, high levels of de-industrialization during 1970-2010 are associated with high unemployment rates and low average income levels in 2010. Our analysis reveals that no significant difference in average income levels, unemployment rates, or human capital levels existed between the resilient and non-resilient municipalities prior to 1970, but that the non-resilient municipalities experienced a reversal of fortune during 1970-2010. Further examination on the differences in industrialization during 1850-2010 between both types of municipalities indicate that the non-resilient municipalities had significant higher shares of employment numbers in the secondary sector, most notably lower skilled industry sectors, as well as a higher level of continuity and specialization in their industry mix. As such, our evidence indicates how a lack of adaptation and diversity in particular manufacturing sectors during the 1850-1970 period limited the non-resilient municipalities in their capabilities to develop new growth paths, rendering these regions unable to adjust to structural changes when de-industrialisation kicked-in after the 1970s.

The remainder of this chapter is structured as follows. In Section 2, we briefly review the patterns of de-industrialization during the past decades in the Netherlands and Belgium. We continue with a description of the model and our panel dataset in respectively Sections 3 and 4. In Section 5, we turn to the results, to end with a brief conclusion in Section 6.

6.2. De-industrialization in the Netherlands and Belgium (1970-2010)

Contrarily to popular belief which associates the disappearance of manufacturing jobs with a poor economic performance, de-industrialization is not necessarily a sign of a failing economy. In contrast, in most regions of the developed world, the decline of the manufacturing sector occurred as a consequence of successful economic development, due to rapid productivity growth in the manufacturing sector, a result of technological change and innovation (e.g. Baumol, Blackman and Wolff 1989; Rowthorn and Ramaswamy 1999), a demand-sided shift from manufacturing products to services (e.g. Clark 1957), and the growth of trade between developed and developing countries (e.g. Wood 1995; Saeger 1996). In these cases, de-industrialization highlights a beneficial economic trajectory in which countries slowly shift from a manufacturing-centred economy to an economy in which employment in services increased in importance.

Both winners and losers emerged as a result of this process of economic growth and de-industrialization, which gave rise to differences both across as within countries. Taking a look at Belgium and the Netherlands during 1970-2010, we notice that the Netherlands were much more able to sustain the disappearance of manufacturing jobs compared to Belgium. In general, about 58% of all manufacturing jobs in Belgium disappeared during the 1970-2010 period, whereas in the Netherlands only a 18% decline occurred. Taking a closer look at the sectoral composition in Table 37, these trends seems to be the result of two evolutions. First, the industry mix in Belgium appears to have been dominated more by industries that saw a more significant disappearance of manufacturing jobs, such as the textiles and basic metal industries. Second, overall, the Netherlands seemed more adequate in attracting new industries compared to

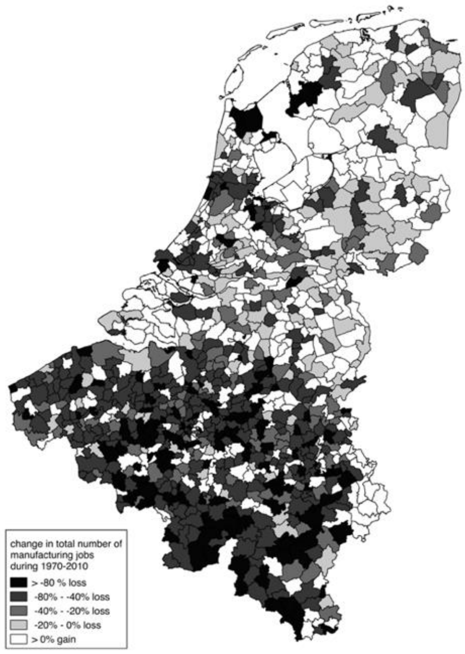
Belgium, with the former country being able to enlarge the labour force in fabricated metal products and miscellaneous products compared to the drastic decline of both sectors in Belgium.

Table 37. Change in number of manufacturing jobs in Belgium and the Netherlands during 1970 – 2010, across groups of ISIC divisions 10-33

	Belgium			the Netherlands		
	1970	**2010**	**Diff.**	**1970**	**2010**	**Diff.**
Food, beverages and tobacco (ISIC 10-12)	148.838	99.284	-33 %	179.589	118.900	-34 %
Textiles, apparel and leather (ISIC 13-15)	228.398	29.849	-87 %	73.604	18.454	-75 %
Wood products and furniture (ISIC 16, 17, 31)	248.727	28.820	-88 %	59.288	45.311	-24 %
Paper, printing and publishing (ISIC 17-18)	72.782	32.768	-55 %	72.803	51.815	-29 %
Chemical products (ISIC 19-22)	107.112	93.646	-13 %	127.621	103.859	-19 %
Non-metallic mineral products (ISIC 23)	61.001	30.375	-50 %	43.520	28.485	-35 %
Basic metal industries (ISIC 24)	70.225	30.983	-56 %	43.279	22.001	-49 %
Fabricated metal products (ISIC 25)	116.497	60.933	-48 %	52.752	94.171	+79 %
Computer and electronic products (ISIC 26-27)	31.282	29.085	-7 %	115.306	104.161	-10 %
Machinery (ISIC 28)	111.362	34.826	-69 %	100.447	81.024	-19 %
Transport products (ISIC 29-30)	53.391	37.860	-29 %	83.642	43.452	-48 %
Other products and repair (ISIC 32-33)	29.509	30.051	+2 %	26.613	92.346	+247 %
Total	**1.279.124**	**538.480**	**-58%**	**978.464**	**803.979**	**-18%**

Yet, not only across both countries, also within countries large differences in de-industrialization emerged over the last forty years. In Figure 31, we notice that the municipalities in Belgium experienced a larger decline in employment of manufacturing. In particular, in Belgium, the disappearance of manufacturing jobs seems to have clustered in the south of the country near the cities of Mons, Dinant, and Bastogne, and in the north of the country near the cities of Aalst and Aarschot. Yet, on a more granular level, we find that some regions in the Netherlands suffered a comparable decline compared to the Belgian regions. In this process, the regions in the direct vicinity of Rotterdam and Amsterdam seem to have participated, but also smaller clusters in the north and east of the Netherlands faced a similar loss of manufacturing jobs.

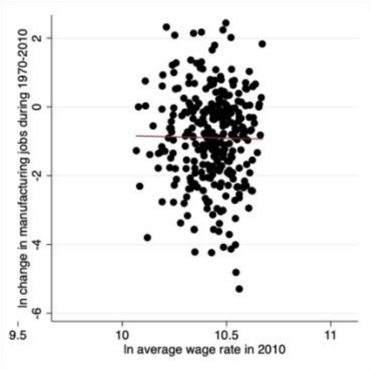
Figure 31. Change in total number of manufacturing jobs in Belgium and the Netherlands during 1970 – 2010 relative to the total number of manufacturing jobs in 1970

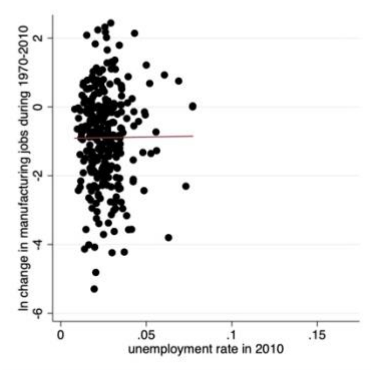


Yet, as aforementioned, the question remains open to which degree the disappearance of manufacturing jobs translated in economic decline. To get a first glimpse on this question, we plot in Figure 32 the correlation across the Belgian and Dutch municipalities between the disappearance of jobs in manufacturing and three different indicators of economic performance in 2010: i.e. average income levels, unemployment levels, and the people with a bachelors and master's degree, the latter as a proxy of human capital. Given the insignificant correlation in Figures 32a-32c (respectively -0.0133, 0.0069 and 0.0581), we can assume that the disappearance of manufacturing jobs during 1970-2010 did indeed not automatically translate into economic misfortune in 2010.

Indeed, Figures 32a-32c illustrate that the loss of manufacturing jobs during 1970-2010 is not associated with a lower economic performance in 2010. So, we can hypothesize that most regions in the Netherlands and Belgium were not only economically mixed, with manufacturing jobs encompassing only a relatively small share of the total labour force, or that in most regions in the Netherlands and Belgium the loss of manufacturing jobs was adequately remedied by the emergence of new economic activities or existing mechanisms of redistribution.

Figure 32. Correlation between the decline of manufacturing jobs in Belgium and the Netherlands during 1970 - 2010 and economic performance in 2010





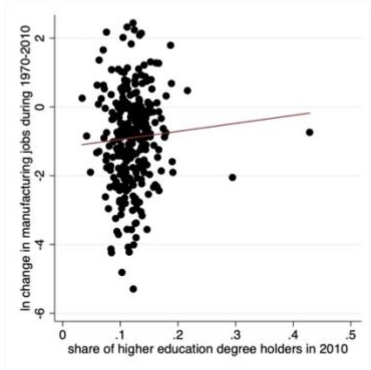


Figure 32a. Correlation between the decline of manufacturing jobs in Belgium and the Netherlands during 1970 - 2010 and the income level in 2010

Figure 32b. Correlation between the decline of manufacturing jobs in Belgium and the Netherlands during 1970 - 2010 and unemployment rate in 2010

Figure 32c. Correlation between the decline of manufacturing jobs in Belgium and the Netherlands during 1970 - 2010 and share of people with a degree of higher education in 2010

Moreover, these findings put the aforementioned case-studies of rust belts (e.g. Grabher 1993; Doussard, Peck and Theodore 2009; Hobor 2016) in a different, more nuanced, perspective. Often, such studies argued how rust belt regions emerged as a direct result of a sudden, drastic fall in employment in the last decades, for which the size of industrial activities previous to de-industrialization were too large to be compensated by new economic activities. Yet, the findings in Figures 2a-2c illustrate that the loss of manufacturing jobs alone do not suffice as an explanation of the economic decline in rust belt regions, and that not all former heavy industrialized regions succumbed to a lower standard of living.

In light of these findings, in the next paragraphs, our quest is twofold. First, identifying the municipalities in the Netherlands and Belgium where the disappearance of manufacturing jobs during 1970-2010 can indeed explain economic misfortune in 2010. Second, exploring how the economic trajectory was different in the non-resilient municipalities compared to the resilient municipalities in the Netherlands and Belgium in the long run, during 1850-2010.

6.3. Model: measuring resilience against de-industrialization

To distinguish between resilient and non-resilient municipalities, we run a self-selecting switching regression model in which we explain unemployment levels in 2010 by the level of de-industrialization during 1970-2010 and several indicators of the local economic performance in 1970, in which we assume that this relation might be different across groups of municipalities based on their paths of industrialisation during 1850-1970. In other words: we assume that for the non-resilient municipalities unemployment in 2010 can be explained by the loss of manufacturing jobs during 1970-2010, whereas this is assumed to have an insignificant effect for the resilient municipalities. The model is specified as follows:

$$y_i = x_i^T \beta + d_i w_i^T \eta + \varepsilon_i, \text{ where } \varepsilon_i \sim \begin{cases} N(0,\sigma_0^2) \text{ if } d_i = 0 \\ N(0,\sigma_1^2) \text{ if } d_i = 1 \end{cases},$$
$$d_i = \begin{cases} 1, \text{ if } \tilde{d}_i > 0 \\ 0, \text{ else} \end{cases} \text{ with } \tilde{d}_i = z_i^T \gamma + u_i,\ u_i \sim N(0,1) \qquad \textbf{(19)}$$

Hence, we combine a probit based selection procedure and a switching regression model in a single estimator. So, rather than choosing a set of variables a priori or assuming that a particular region should or should not be categorized as a rust belt region, we allow the data and model to select the group members of the resilient and non-resilient municipalities. We only tell the model which variables should determine if a particular municipality belongs to the category of resilient or non-resilient municipalities, and we allow the model to choose the parameters so that the model fits the best. The coefficient vectors β and η are the effect of explanatory variables included in the vectors *x* and *w* (*x*=*w* is a logical initial choice) but *w* can be a subset of *x*. In this setup, we assume that both coefficients would be different for the two groups. The variables in vector *z* are the factors determining whether a municipality i belongs to the group of resilient or non-resilient municipalities.

With our method, we take the unemployment rate in 2010 as our variable *y*, while *x* and *w* contains both the loss of manufacturing jobs during 1970-2010 and five additional variables which proxy the economic performance in 1970: the unemployment rate, the average income level, the level of human capital, population density, the level of specialization in the economic structure, and the size of a region. Vector *z* contains the variables that proxy the capabilities of municipalities to overcome de-industrialization, for which we take the relative share of industrial employment in the total labour force in 1850, 1890, 1930, and 1970. In this perspective, we consider that the capacities of regions to compensate the loss of manufacturing activities will be determined by the height and long-run presence of employment in industry prior to 1970. Moreover, by not including data on economic development in the past in the probit, we allow the model merely to identify the non-resilient municipalities based on the economic structure in the past and not let past levels of economic development directly influence the identification strategy.

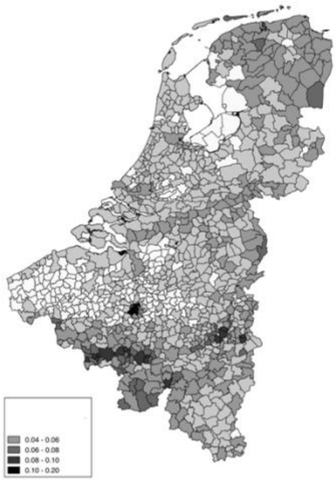
6.4. Constructing a panel dataset on local economic growth

As regards to data, we composed a large panel dataset for all present-day municipalities in Belgium and the Netherlands, which corresponds to the LAU2 (*Local Administrative Unit*) level in the NUTS (*Nomenclature of Territorial Units for Statistics*) framework of the European Union. As such, we collapsed the historical municipalities of the 1850-1970 period to the LAU2 or present-day municipal geographical boundaries of 2010. In the Netherlands, the number of municipalities reduced gradually during the studied time frame, from 1.236 in 1817 to 431 municipalities in 2010, with most mergers taking place during the second half of the twentieth century (Van der Meer and Boonstra 2011). Conversely, in Belgium 2.499 municipalities in 1830 were re-organized to 2.585 municipalities in 1970. After a series of large municipal reforms, only 589 municipalities remained in 1983 (De Belder, Vanhaute and Vrielinck 1992), a number that remained constant until 2010. Although the number of municipalities might have changed considerable during the studied period, the geographical boundaries of these municipalities remained more or less constant over time.[75] As the territories of nearly all collapsed municipalities merged completely within another, with few to no border changes, potential modifiable unit area problems are minimal. Furthermore, in order to make a standardized panel dataset for the entire 1850-2010 period, we exclude two sets of municipalities which were annexed to both countries in the course of the twentieth century: the former German departments which Belgium acquired as compensation for the first World War and Flevoland which was reclaimed from the sea by the Netherlands during the 1920s-1970s.[76]

Figure 33. Unemployment rate in 2010

[75] In Belgium during the municipal reforms of 1970-1977, 2.311 changes were made to the municipal boundaries. Here, 2.062 changes concerned the merging of the territory of a municipality to another municipality in its entirety, 246 changes concerned the merging of the territory of a municipality to a group of municipalities, 1 change of the boundary of a municipality, and 2 changes in the name of a municipality (De Belder, Vanhaute and Vrielinck 1992). For the Netherlands, when taking the province of Drenthe as a reference point, it appears that of the 31 changes, 17 changes concerned the merging of the territory of a municipality to another municipality in its entirety, 12 changes concerned the merging of the territory of a municipality to a group of municipalities, and 2 changes were made in the name of a municipality (Van der Meer and Boonstra 2011).

[76] Both regions are small in terms of manufacturing jobs. So, did Flevoland compromise 1,61 % of the total employment in industry in the Netherlands in 2010. Similarly, do the *Ostbelgien* - the annexed former-German municipalities - compromised 0,99 % of the total employment in industry in Belgium in 2010. Ostbelgien compromises 11 municipalities, whereas Flevoland compromises 5 municipalities. Thus, by excluding both regions, our number of observations is 1006.



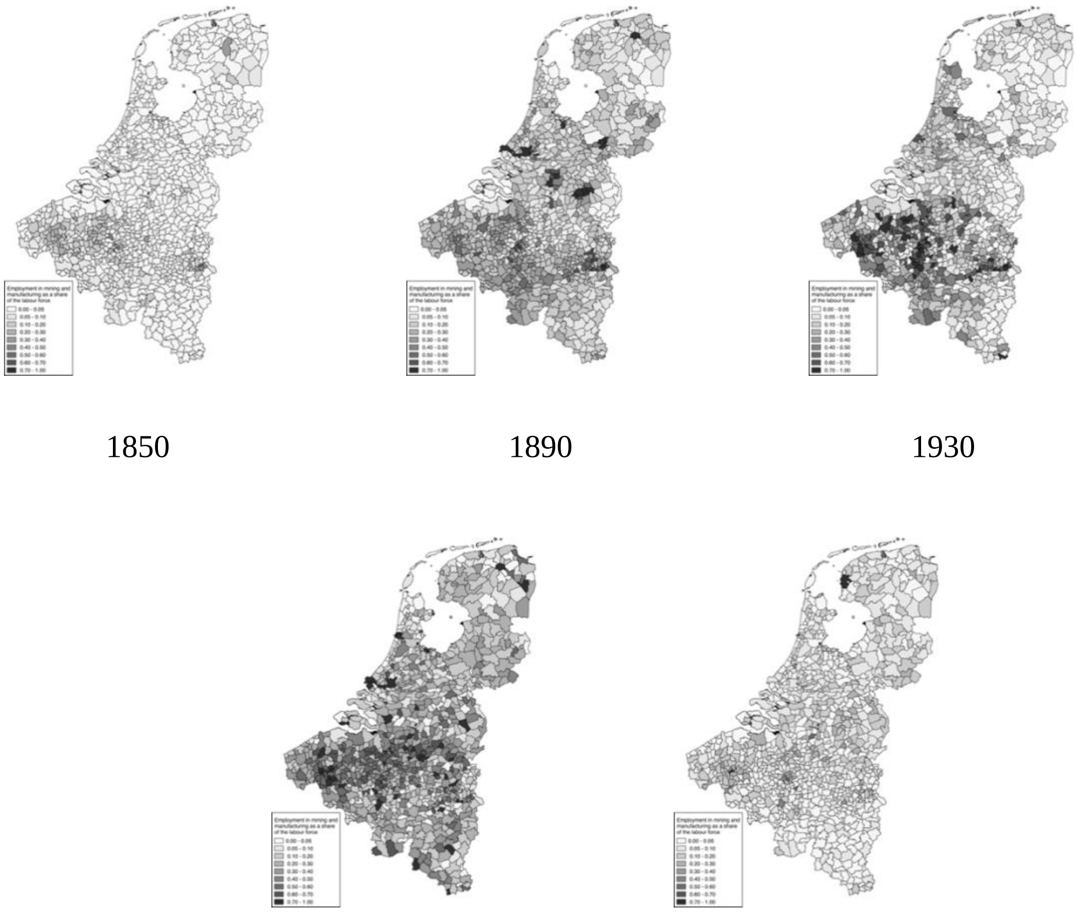
As aforementioned, we regress our independent variable – unemployment in 2010 on the municipal (LAU2) level – against a set of 1970 variables: the loss of manufacturing jobs during 1970-2010, the unemployment rate, the average income level, an indicator of human capital, the diversity in the economic structure, the size of a municipality, and the population density. In particular, we measure the diversity in the economic structure with a Krugman specialization index of the primary-secondary-tertiary economic structure per municipality, and we take the bachelor and master degree holder equivalents as an indicator of human capital. All these numbers were obtained from the 1970 and 2011 Belgian censuses of population, the 1970 industry census and the 2010 RSZ statistics for which the latter provides data about the labour force on the LAU2 level. For the Netherlands, we turned to the 1971 and 2011 censuses of population, the 1978 industry census, and the LISA dataset, the latter which documents the labour force across economic sectors on the LAU2 level.

As the independent variable, we take the unemployment rate or the percentage of unemployed people in the total active population in 1970 and 2010. Figure 33 shows how unemployment levels in 2010 seem to cluster in Belgium around the larger cities, affecting in particular the cities of Brussels, Antwerp, and Liège, and disproportionally the south of Belgium (Wallonia). In the Netherlands, unemployment levels clustered in the cities of Amsterdam and Rotterdam, although higher unemployment levels could be found in the northern and eastern parts of the country.

Second, we add data on employment in the manufacturing sectors in 1850, 1890, 1930, and 1970, for which we turn to the industry censuses in both countries. For 1850 and 1890, we turn to the Belgian industry censuses of 1846 and 1896, whereas for the Netherlands we use the

Condition of the Dutch Factories in 1857 (Nederlandsche Maatschappij 1859) and a large collection of Dutch municipal reports in 1896 as collected by Philips (2019). For Belgium, we turn to the 1937 and 1970 industry census and for the Netherlands the 1930 and 1978 industry census.

Figure 34. Employment in industry as a percentage of the labour force



1850 1890 1930

1970 2010

Based on Figure **3**4, it is clear that industrialization in the Netherlands and Belgium faced notable spatial patterns during the 1850-2010 period. In Belgium, we find during the nineteenth century two regions dominating: a textiles heartland in north-western Flanders, and the southern Walloon area, where heavy machinery and metallurgy activities emerged near the coal belt between Liège and Mons. The ability to attract new industries and multinational companies in Brussels and Antwerp stimulated the rise of industries in the north-eastern part of Flanders during the twentieth century, whereas the southern Walloon region faced a relative standstill (e.g. De Brabander 1984; Buyst 2018). In the Netherlands, the western regions encompassed the industrial heartland during the studied period in absolute numbers, confirming the Randstad as the most urbanised and prosperous part of the country since early modern times (e.g. Van Zanden and Van Leeuwen 2012). During the nineteenth century, the eastern and southern Dutch regions benefitted from industrialization as well (e.g. Atzema and Wever 1994). After the 1950s, many of these industries relocated, closer to the harbours of Rotterdam and Amsterdam, and several smaller clusters, predominantly in the southern part of the country.

Third, we set out to explore the differences in economic performance between the resilient and non-resilient municipalities in the long-run. For this, we collect data on the 1850-2010 period for four indicators of economic growth on the LAU2 level: average income, unemployment rate, human capital, and population density. For population density, measured as the per square kilometre number of inhabitants, statistics were retrieved from the Belgian population censuses of 1846, 1896, 1937, and 1970, 2010 and the Dutch population censuses of 1849, 1899, 1930, 1971, and 2011. For the Belgian case, much of this data had been digitized by the Quetelet center, whereas the HED (Historical-Ecological Database) digitized much for the Dutch case (Beekink et al. 2003). The unemployment rate could be obtained from the aforementioned population censuses. For human capital: for 1850, 1890 and 1930, we turn to literacy rates as a proxy, obtained from the population censuses, given the lack of alternative data on the LAU2 level about human capital. In addition, we calculated the share of the population with a secondary school degree and degree of higher education (bachelor, master, or equivalent) as a proxy of human capital in 1970 and 2010. For the Netherlands, we calculated the average literacy per municipality in 1850, 1890, and 1930 by using the HSN (Historical Sample of the Netherlands) dataset, whereas we turned to the statistics collected by the CBS for 1970 and 2010 to measure the share of the population with a degree of secondary school and higher education.

For the average income level, we take the closest available proxy of wealth available for the entire 1850-2010 period: taxable income per capita. For the statistics on tax revenues in Belgium, we used the taxable income base of real estate and land taxation for 1846, 1896, and 1937, as reported in the respective censuses of population. For 1970, we used the taxable income base on land and buildings as reported in the 1970 population census. For 2010, we turned to Belgian office of statistics.[77] For the Netherlands in 1850 and 1890, we used the land

[77] STATBEL (2010). Bodembezetting op basis van het kadasterregister per gemeente / Land use based on the cadastral register by municipality. Online accessible via https://bestat.statbel.fgov.be/bestat/crosstable.xhtml?datasource=b5c5eedc-95bf-4927-929e-d6395345a53a (accessed on 23/11/2018).

and personal tax revenues of 1859 and 1889, digitized by the aforementioned HDNG/HED database. For 1930, we used the revenue from income taxes as reported in the Handbook for Market Research in the Netherlands of 1935. As the Dutch statistical office (CBS) did not document statistics on taxable revenues on regional levels prior to the Valuation of Immovable Property Act of 1994, we used the average housing value multiplied with the number of houses in 1994 as a proxy for 1970, and did the same for 2010.[78]

In addition, to verify whether former industry clusters enjoyed long-lasting benefits due to higher investment in public infrastructure, we collected data on public transport infrastructure as a proxy. In particular, we measured the length of railroads, primary roads, and secondary roads in each municipality by digitizing the topographic maps. For 1930, we turned to the Belgian topographic maps of 1930-1951 and for the Netherlands the topographic maps of 1924-1938. Also, we digitized the Belgian topographic maps of 1973 and 2009 and the Dutch topographic maps of 1970 and 2010. Furthermore, we can hypothesize that regions with a proximity to nearby labour markets would have been more able to compensate the loss of manufacturing activities by commuting. Therefore, we proxied commuting with the share of the working population who shared within the same municipality their work place and place of living. For Belgium in 1970 and 2010, we turned to the aforementioned population censuses. For the Netherlands, we turned to the population census of 1978 and the 2014 statistics of the Dutch statistical office.[79]

Fourth, to account for the theories which argued that the economic structure determined the regional capabilities to respond to shocks, we take the relative employment numbers in the primary-secondary-tertiary sector. For Belgium, we take the employment in agriculture from the agricultural censuses of respectively 1846 for 1850, 1895 for 1890 and 1930 for 1930, and 1971 for 1970, in addition to the number of agriculture workers in 2010 as reported in the RSZ statistics. For the Netherlands, we turned for 1850 and 1890 to the HSN database, for which we measured the relative share of people with an occupation in agriculture per municipality. In addition, we turned to employment numbers in agriculture, as recorded in the population

[78] CBS, Statistics Netherlands (2010). Regionale kerncijfers Nederland / Regional highlights Netherlands. Online accessible via https://opendata.cbs.nl/statline/#/CBS/nl/dataset/82801NED/table?ts=1554214212600 (accessed on 23/11/2018).

[79] CBS, Statistics Netherlands (2014). Banen van werknemers naar woon- en werkregio / Jobs of employees according to home and work region. Online accessible via https://opendata.cbs.nl/statline/#/CBS/nl/dataset/83628NED/table?fromstatweb (accessed on 23/09/2019).

censuses of 1930, and 1971, and the LISA statistics for 2010.

For employment in tertiary activities in Belgium, we take the employment in tertiary activities as stated in the industry censuses of 1846, 1896, and 1937. For the Netherlands in 1850 and 1890, we calculated the employment in services as the relative share of people with an occupation in services per municipality from the HSN dataset. For 1930, we turned to the Dutch industry census of 1930. For 1970 and 2010 in the Netherlands, we turned to the aforementioned industry census of 1978 and the 2010 statistics in the Dutch LISA register. For Belgium, we turned to the aforementioned industry census of 1970 and the 2010 statistics of the Belgian Office of Social Security Service. Notwithstanding that all aforementioned sources for the 1850-1970 period notoriously only present a partial picture of the total employment in the tertiary sector, we assume that the geographical variation in the limited services activities is representative for the geographical variation in the total tertiary sector.

Lastly, given the importance of the industry sector for explaining de-industrialization, we collect three additional groups of data on this sector. First, we split up the employment numbers from the aforementioned sources across different sub-sectors of manufacturing. Second, to accommodate the literature which argued how industrialization favoured particularly low-skilled labour, we apply the subdivision of manufacturing sub-sectors according to knowledge-intensity made by EUROSTAT.[80] Third, to assess the theories that pointed to the role of diversification in rust belt areas, we calculate a Krugman specialization index (KSI) based on the aforementioned employment numbers in manufacturing sub-sectors. Fourth, to measure adaptation or change in the location of industry, we introduce an inherited industry ratio (IIR), following Nikolic (2018). We calculate this ratio as the total number of employees in sector *s* in region *r* and year *t* divided by the total number of employees in sector *s* in region *r* and year *t*-1, after which we take the sum of all sectoral shares for each municipality *r* in each year *t*.

[80] EUROSTAT (2016). High-tech industry and knowledge-intensive services. Annex 2 – High-tech aggregation by NACE Rev 1.1. Online accessible via https://ec.europa.eu/eurostat/cache/metadata/en/htec_esms.htm (accessed on 01/10/2018).

6.5. Results

6.5.1. Identifying the resilient and non-resilient municipalities

As aforementioned, we explain the unemployment level in 2010 with the number of lost manufacturing jobs during the 1970-2010 period, as well as a set of variables that proxy the local economic situation in 1970: the unemployment rate, the average income, the level of specialization in the labour force, the share of the population with a bachelor or master degree as a proxy of human capital, the population density and the size of the region. In addition, we assume that this effect is different between two groups: one group which is resilient against de-industrialization and one group which is not.

In Table 38, our model distributed the municipalities of the Netherlands and Belgium in one large group of type A municipalities and one smaller group of type B municipalities. For the type A municipalities, we find that the unemployment levels in 2010 are negatively associated with the average income level in 1970 and the change in manufacturing jobs during 1970-2010 and positively associated with the unemployment rate and the level of population density in 1970. This finding indicates economic continuity for the type A municipalities, with the municipalities with a high unemployment rate in 2010 encompassing municipalities that were also endowed with a lower average income level and a higher level of unemployment in 1970. For these type A municipalities, the found negative association between the change in manufacturing jobs during 1970-2010 and the unemployment level in 2010 reveals that a high loss of manufacturing jobs is associated with a low level of unemployment, indicating how in these regions the loss of manufacturing jobs did not hinder local economic growth.

Yet, we find very different results for the type B municipalities. For the type B municipalities, we find that the unemployment rate in 2010 is positively associated with the change in manufacturing jobs during 1970-2010, the unemployment rate, the average income level and the share of population with a degree of higher education in 1970. Yet, we find a negative association of the unemployment rate in 2010 with population density in 1970. This indicates that a reversal of fortune occurred for these type B municipalities: the type B municipalities with a high unemployment rate in 2010 encompass municipalities which have a low unemployment rate in 1970, but a high average income. In addition, whereas the type A municipalities concern predominantly population dense municipalities, the found reverse effect of population density for the type B municipalities indicates that these municipalities were rather population sparse regions. Turning to our main variable of interest, we find a negative association of manufacturing jobs during 1970-2010 with unemployment in 2010. This indicates that the municipalities with a high loss of manufacturing jobs are associated with a high level of unemployment, indicating that for these municipalities the loss of industrial activities were not compensated and actually is linked with the economic reversal of fortune for these regions.

Table 38. Estimation results for the effect of change in manufacturing jobs (1970-2010) on the unemployment rate in 2010 between Type A and B municipalities

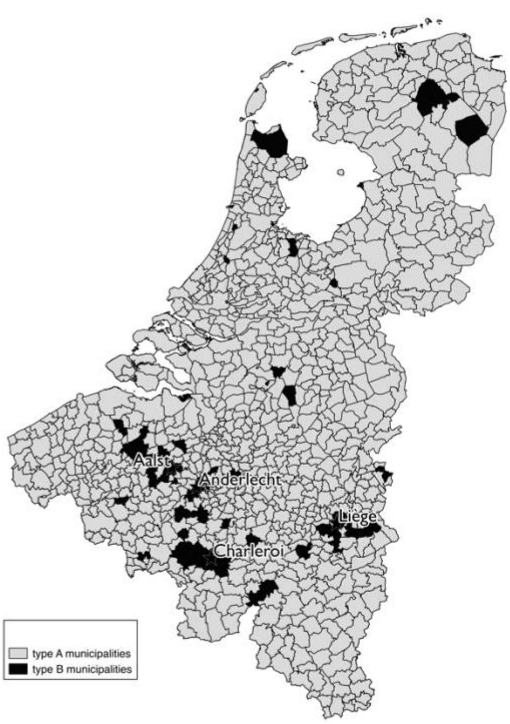
	(1)	(2)
	dependent variable: unemployment rate in 2010	
	Type A	Type B
Unemployment rate in 1970	0.112*	0.124*
	(0.0658)	(0.0690)
ln Change in manufacturing jobs during 1970-2010	-0.00759***	0.00821***
	(0.00172)	(0.00172)
Share of population with degree of higher education in 1970	-0.0693	0.159***
	(0.0537)	(0.0611)
Ln Average level of income in 1970	-0.0211***	0.0199***
	(0.00287)	(0.00285)
Krugman specialization index in 1970	-0.00858	0.0136
	(0.00879)	(0.00894)
Size of region in km^2 in 1970	0.00193	-0.000658
	(0.00314)	(0.00310)
ln Population density in 1970	0.0128***	-0.0138***
	(0.00196)	(0.00206)
Constant	0.173***	-0.153***
	(0.0323)	(0.0311)
$ln(\sigma_A^2)$ *and* $ln(\sigma_B^2)$	-4.259***	-5.056***
	(0.0832)	(0.0649)
the selection part		
Relative employment in industry in 1850	4.782***	
	(0.885)	
Relative employment in industry in 1890	-4.179***	
	(1.073)	
Relative employment in industry in 1930	0.633	
	(0.430)	
Relative employment in industry in 1970	-1.453***	
	(0.997)	
Constant	-1.030***	
	(0.146)	
Country dummies	yes	
Number of observations	1003	
	923	80
Log(pseudolikelihood)	3200.638	
Wald chi2(4)	323.21	
Prob > chi2	0.0000	

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

All in all, we find for the type A municipalities an economic continuity during 1970-2010, whereas a reversal of fortune during 1970-2010 seems to have occurred for the type B municipalities, a process in which the loss of manufacturing jobs during 1970-2010 seems to have been associated with the latter's economic downfall. As such, in the following sections, we refer to the former category of municipalities as the municipalities resilient against de-industrialization and the latter category of municipalities as the non-resilient municipalities.

As found in Table 38, the specification subdivided the municipalities in the Netherlands and Belgium in two groups: one large group of type A municipalities which proved resilient against de-industrialization during 1970-2010, encompassing 923 municipalities, and one smaller group of type B or non-resilient municipalities, encompassing 80 municipalities. Among these type B municipalities, we find that Belgium was more represented than the Netherlands: 14 municipalities in the Netherlands and 66 municipalities in Belgium are categorized as Type B municipalities. As noted in Section 2, given the relative higher disappearance of manufacturing jobs during 1970-2010 in Belgium compared to its northern neighbour, this is no surprise.

Figure 35. Distribution of resilient and non-resilient municipalities



In Figure 35, we map the resilient and non-resilient municipalities. For the non-resilient municipalities in the Netherlands, we find that these municipalities are somewhat dispersed across the country, though predominantly located in the north of the country. Yet, for Belgium, we find that the majority of the non-resilient municipalities are clustered in four centres. A first and second cluster is found near the cities of Charleroi and Liège. Both clusters are located in the former heartland of the Mons-Liège manufacturing belt in Belgium, where since the early nineteenth century next to coal facilities metallurgy and glass factories arose. Yet, due to the disappearance of these sectors during the second half of the twentieth century, this region became generally acknowledged as a rust belt region. A third cluster can be found near the city of Aalst, a region that arose as a centre of textiles production since the middle of the nineteenth century. A fourth cluster is found in the southeast suburban part of the metropolitan area of Brussels, with the centre of this cluster lying in the municipality of Anderlecht. All in all, our results indicate that next to the archetypical rust belt region in Belgium, roughly alongside the Liège-Mons axis, more regions in the Netherlands and Belgium experienced similar patterns of economic decline as a result of de-industrialization.

6.5.2. Difference in economic development between resilient and non-resilient municipalities

Next, in order to explore the differences between the resilient and non-resilient municipalities in terms of long-run economic performance, we calculated the statistical significance in variance or d_i across the resilient and non-resilient municipalities during the 1850 – 2010 period for two indicators of local economic growth: unemployment and average income. We reported the results in Table 39.

For the unemployment rate, we find that the non-resilient municipalities had a higher unemployment rate in 1890 and 1970, but not in 1930. In 2010, the unemployment rate appears significantly higher in the non-resilient municipalities compared to the resilient municipalities, on average 2.6%. For the average income level, we find that the non-resilient municipalities were endowed with a significantly higher income level in 1850 and 1890, but the difference had turned insignificant during 1930-1970, to become significantly lower compared to the resilient municipalities in 2010, when the average wage was on average 14% lower in the non-resilient municipalities. As such, we can assess that the non-resilient municipalities had no signs of economic depravity prior to the loss of manufacturing jobs during 1970-2010, but are at present confronted with lower economic growth.

Table 39. Estimation results for the variance between the resilient and non-resilient municipalities in unemployment and average income levels

	[1] 1850	[2] 1890	[3] 1930	[4] 1970	[5] 2010
d_i in unemployment		0.0139***	-0.00265*	0.00491***	0.0262***
		(0.00419)	(0.00160)	(0.00187)	(0.00364)
Constant		0.0180***	0.0247***	0.0240***	0.0276***
		(0.000794)	(0.000725)	(0.000484)	(0.000468)
R-squared		0.015	0.008	0.043	0.134
d_i in average income	0.120**	0.259***	0.107	0.173	-0.144***
	(0.0603)	(0.0709)	(0.103)	(0.108)	(0.0221)
Constant	5.234***	5.585***	7.464***	8.753***	10.38***
	(0.0217)	(0.0277)	(0.0316)	(0.0485)	(0.00512)
R-squared	0.003	0.007	0.001	0.001	0.057

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 40. Estimation results for the variance between the resilient and non-resilient municipalities in human capital

	[1] 1850	[2] 1890	[3] 1930	[4] 1970	[5] 2010
d_i in literacy rate	-0.158***	-0.0801***	-0.0267***		
	(0.0219)	(0.0148)	(0.00686)		
Constant	0.663***	0.797***	0.944***		
	(0.00725)	(0.00467)	(0.00182)		
R-squared	0.037	0.023	0.017		
d_i in degree of secondary school education				0.119***	0.0299***
				(0.0227)	(0.0110)
Constant				0.281***	0.102***
				(0.00857)	(0.00318)
R-squared				0.016	0.007
d_i in degree of higher education				0.0295***	0.0330***
				(0.00552)	(0.0109)
Constant				0.0525***	0.0569***
				(0.00174)	(0.00267)
R-squared				0.023	0.012

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Even more, given the association of economic development with human capital in many narratives on rust belt regions (e.g. Glaeser 2005; Kitsos and Bishop 2016), we also measure the statistical significance in variance for various indicators of human capital for the 1850-2010 period. In Table 40, we find that the non-resilient municipalities had a lower literacy rate in 1850, 1890, and 1930. As such, these findings affirm the views of Franck and Galor (2017) that present-day rust belt regions faced a historical low accumulation of human capital during the nineteenth century. Although we have to be aware that literacy rates do not necessarily present a representative image of human capital in 1930, a time when the vast majority of the population is literate, the declining regression coefficients and coefficients of determination for 1850-1930 indicate how compulsory education removed to a large extent the lower human capital rate in early industrialized regions during the 1850-1930 period. Likewise, we find that the share of the population with a degree of secondary schooling and higher education was higher for the non-resilient municipalities, in 1970 and 2010. As such, our evidence indicates that the differences between resilient and non-resilient municipalities cannot be explained by human capital.

In addition, one could argue that differences in population growth might explain the divergence between resilient and non-resilient municipalities. In Table 41, we therefore measure the difference in terms of population and population density. We find that municipalities which were not resilient against de-industrialization during 1970-2010 had indeed a larger population during 1890-2010. Yet, the coefficient of determination reveals that this difference is not highly significant. Moreover, the non-resilient municipalities appear on average less population dense in 1850, 1890, and 1930. By 1970, population density appears higher for the non-resilient municipalities, but less high by 2010. Yet, the low coefficient of determination affirms that also population density cannot explain the difference between the resilient and non-resilient municipalities.

Table 41. Estimation results for the variance between the resilient and non-resilient municipalities in population and population density

	[1] 1850	[2] 1890	[3] 1930	[4] 1970	[5] 2010
d_i in population	-0.0654	0.526***	0.545***	0.468***	0.265***
	(0.143)	(0.121)	(0.120)	(0.112)	(0.0984)
Constant	8.491***	8.798***	9.061***	9.428***	9.645***
	(0.0290)	(0.0284)	(0.0294)	(0.0320)	(0.0320)
R-squared	0.000	0.026	0.026	0.017	0.006
d_i in population per km^2	-0.779***	-0.257**	-0.261*	1.072***	-0.514***
	(0.127)	(0.123)	(0.157)	(0.156)	(0.187)
Constant	2.876***	3.385***	3.591***	5.594***	4.068***
	(0.0507)	(0.0485)	(0.0535)	(0.0354)	(0.0655)
R-squared	0.019	0.002	0.002	0.065	0.005

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Furthermore, we have to consider that commuting might bias the results, as municipalities with an extensive number of commuters to other regions might be more able to overcome a decline of manufacturing jobs within its own region. As a proxy of commuting, we therefore measure the difference between resilient and non-resilient municipalities in the share of the working population which shares their place of work with their place of residence in a given municipality. The results in Table 42 indicate no significant difference in 1970, but that in 2010 fewer people in the non-resilient municipalities shared their working and living place. This finding could indicate that de-industrialization pushed the population in non-resilient municipalities to seek employment opportunities elsewhere. Lastly, in order to determine whether investment in public infrastructure could explain the divergence between resilient and non-resilient municipalities, we measure the difference in terms of railroads, primary roads, and secondary roads in Table 43. Given the low coefficient of determination in these results, our evidence indicates that the non-resilient municipalities were not different endowed with public infrastructure, neither before or after the period of de-industrialization.

Table 42. Estimation results for the variance between the resilient and non-resilient municipalities in commuting

	[1] 1970	[2] 2010
d_i in share of working population with shared place of work and residence	-0.00140	-0.0215***
	(0.0268)	(0.00543)
Constant	0.562***	0.301***
	(0.00540)	(0.00285)
R-squared	0.000	0.005

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

All in all, it appears that the non-resilient municipalities showed no signs of economic depravity prior to 1970, before these regions lost manufacturing jobs due to de-industrialization. The resilient and non-resilient municipalities are shown not to differ in terms of unemployment rates, average income levels, public infrastructure investment, human capital, or population density. Yet, by 2010, the non-resilient municipalities had deviated strongly from the resilient municipalities, with an on average 14% lower income level and an on average 2% higher unemployment rate compared to the resilient municipalities.

Table 43. Estimation results for the variance between the resilient and non-resilient municipalities in public infrastructure

	[1]	[2]	[3]

	1930	1970	2010
d_i in length of railroads	8,138**	4,645*	1,151
	(3,673)	(2,562)	(1,603)
Constant	12,790***	9,840***	6,889***
	(568.5)	(460.6)	(405.1)
R-squared	0.013	0.007	0.001
d_i in length of primary roads	-2,360	-3,285*	-4,209*
	(1,991)	(1,867)	(2,213)
Constant	16,095***	16,007***	15,920***
	(530.3)	(472.7)	(592.6)
R-squared	0.002	0.004	0.004
d_i in length of secondary roads	-26,168**	-255.9	25,657
	(12,551)	(15,882)	(23,227)
Constant	116,524***	111,918***	107,311***
	(4,301)	(3,703)	(4,888)
R-squared	0.003	0.000	0.002

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

6.5.3. Difference in economic structure between resilient and non-resilient municipalities

Furthermore, we study the long-run differences in the economic structure between the resilient and non-resilient municipalities. In particular, due to the afore-found importance of the loss of manufacturing jobs in the reversal of fortune for the non-resilient municipalities, we focus on the differences in the structure of the secondary sector. We start, in Table 4**4**, with reporting the differences in the employment share of the primary, secondary, and tertiary sector. Here, we find that the non-resilient municipalities were on average less dominated by primary activities. For tertiary activities, we find a diffused pattern: non-resilient municipalities seem to have significantly more tertiary activities in 1850 and 1890, less in 1930, but more in 1970 and 2010. Yet, given the importance of the loss of manufacturing jobs during 1970-2010 for the reversal of fortune of the non-resilient municipalities, our main interest concerns the secondary sector. Here, we find that the non-resilient municipalities during the 1850-1930 period were endowed with a relative higher number of secondary jobs, with an on average 20-23% higher share of relative employment in the secondary sector. Yet, for 1970 and 2010, we find no statistically significant difference between the resilient and non-resilient municipalities in relative employment in the secondary sector. As such, we can assume that the disappearance of manufacturing jobs started during 1930-1970, where as a consequence the difference between non-resilient and resilient municipalities had become statistically insignificant by 1970.

Table 44. Estimation results for the variance between the resilient and non-resilient municipalities in economic structure

	[1]	[2]	[3]	[4]	[5]
VARIABLES	1850	1890	1930	1970	2010
d_i in employment in primary sector	-0.184***	-0.224***	-0.191***	-0.0633***	-0.0164***
	(0.0229)	(0.0290)	(0.0361)	(0.0240)	(0.00132)
Constant	0.540***	0.657***	0.553***	0.266***	0.0251***
	(0.00813)	(0.00780)	(0.0107)	(0.00826)	(0.000984)
R^2	0.093	0.132	0.058	0.012	0.058
d_i in employment in secondary sector	0.239***	0.0533***	0.204***	-0.0117	-0.0279***
	(0.0264)	(0.0109)	(0.0315)	(0.0111)	(0.00423)
Constant	0.0652***	0.104***	0.0960***	0.110***	0.0619***
	(0.00202)	(0.00255)	(0.00330)	(0.00354)	(0.00210)
R^2	0.348	0.032	0.165	0.001	0.015
d_i in employment in tertiary sector	0.109***	0.0547***	-0.0395***	0.0582***	0.0292***
	(0.0299)	(0.0161)	(0.0111)	(0.0219)	(0.00615)
Constant	0.359***	0.148***	0.184***	0.397***	0.852***
	(0.00707)	(0.00370)	(0.00391)	(0.00712)	(0.00251)
R^2	0.040	0.036	0.020	0.013	0.027

Notes: robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Thus, although it seems that the non-resilient municipalities differed considerably from the resilient municipalities in the higher share of secondary sector activities during 1850-1930, one might wonder whether certain secondary activities were more conducive for developing a lack of resilience against de-industrialization. In order to explore this further, we report the variance of the employment share in manufacturing sub-sectors between the resilient and non-resilient municipalities throughout 1850-2010 in Table 45. Here, we find that particular manufacturing sub-sectors were more conducive towards resilience against de-industrialization. For instance, the employment in the production of food and tobacco products, as well as wood and paper products, appear to decrease significantly the likelihood of becoming a non-resilient municipality. In contrast, the likelihood to become a non-resilient municipality appears to increase when facing a high employment in the production of machinery and equipment, or the production of mineral and metal products. Yet, all in all, given that only a low significance is found to explain the variance of non-resilient municipalities, these results rule out that a specialization in a particular secondary sub-sector can fundamentally explain the resilience against de-industrialization.

Table 45. Estimation results for the variance between the resilient and non-resilient municipalities in the structure of the manufacturing sub-sectors

	[1] 1850	[2] 1890	[3] 1930	[4] 1970	[5] 2010
d_i in employment in manufacture of food and tobacco products	-0.141***	-0.123***	-0.177***	-0.0726***	-0.00874
	(0.0102)	(0.00925)	(0.0177)	(0.0121)	(0.0252)
Constant	0.193***	0.183***	0.271***	0.176***	0.261***
	(0.00725)	(0.00643)	(0.0112)	(0.00800)	(0.00946)
R-squared	0.077	0.075	0.052	0.018	0.000
d_i in employment in manufacture of textiles and leather products	-0.0310	-0.00555	0.125***	0.0742**	0.00280
	(0.0451)	(0.0415)	(0.0434)	(0.0331)	(0.0143)
Constant	0.611***	0.446***	0.192***	0.131***	0.0501***
	(0.01000)	(0.00877)	(0.0114)	(0.00848)	(0.00430)
R-squared	0.002	0.000	0.022	0.014	0.000
d_i in employment in manufacture of wood and paper products	-0.0312***	-0.0742***	-0.112***	-0.174***	-0.0221*
	(0.00323)	(0.00799)	(0.0108)	(0.0194)	(0.0123)
Constant	0.0469***	0.133***	0.160***	0.261***	0.121***
	(0.00241)	(0.00409)	(0.00812)	(0.0120)	(0.00581)
R-squared	0.036	0.066	0.041	0.044	0.003
d_i in employment in manufacture of chemicals and plastic products	-0.00295	-0.00426	-0.00186	0.0145	-0.00340
	(0.00216)	(0.00363)	(0.0111)	(0.0152)	(0.0162)
Constant	0.00631***	0.0143***	0.0411***	0.0481***	0.0920***
	(0.00181)	(0.00251)	(0.00531)	(0.00565)	(0.00771)
R-squared	0.001	0.001	0.000	0.001	0.000
d_i in employment in manufacture of minerals and metals products	0.0485**	0.0465*	0.0366	0.0341	0.00208
	(0.0211)	(0.0240)	(0.0264)	(0.0276)	(0.0262)
Constant	0.0696***	0.111***	0.130***	0.159***	0.240***
	(0.00497)	(0.00562)	(0.00796)	(0.00818)	(0.00836)
R-squared	0.016	0.012	0.004	0.003	0.000
d_i in employment in manufacture of machinery and equipment prod.	0.00548***	0.0113***	0.00147	0.00515	0.0146
	(0.00191)	(0.00400)	(0.00976)	(0.0116)	(0.0201)
Constant	0.00236***	0.00461***	0.0490***	0.0618***	0.0875***
	(0.000554)	(0.000907)	(0.00472)	(0.00531)	(0.00574)
R-squared	0.018	0.026	0.000	0.000	0.001
d_i in employment in manufacture of transport and other products	-0.00423*	-0.0213***	-0.0249***	-0.0276***	0.00115
	(0.00222)	(0.00461)	(0.00692)	(0.00901)	(0.0181)
Constant	0.0118***	0.0448***	0.0568***	0.0768***	0.138***
	(0.000842)	(0.00202)	(0.00481)	(0.00553)	(0.00625)
R-squared	0.005	0.023	0.006	0.005	0.000

Notes: robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

In addition, in Table 46, we use the aforementioned EUROSTAT classification to subdivide the manufacturing sectors according to levels of skill intensity. These results reveal that the non-resilient municipalities had a higher share of employment in low skilled industry sectors. Moreover, the coefficient of determination indicates that this difference in variation is highly significant. Likewise, for medium-low skilled industry sectors, we find that the non-resilient municipalities had a significantly higher share of employment. Yet, for medium-high and high skill intensive industry sectors, no such difference appears in place. These findings reveal that the early industrializing regions predominantly specialized in lesser skilled industry sectors, in line with the findings of Franck and Galor (2017) for France. Yet, whereas Franck and Galor (2017) argued that the specialization in low-skilled industries hindered the accumulation of human capital, our evidence present a more nuanced picture: whereas we found in the previous results that human capital levels did not differ significantly between the resilient and non-resilient municipalities, our results seem to indicate that informal skills seems to have been more fundamental in the reversal of fortune of the non-resilient municipalities.

Table 46. Estimation results for the variance between the resilient and non-resilient municipalities in the structure of the manufacturing sub-sectors

	[1] 1850	[2] 1890	[3] 1930	[4] 1970	[5] 2010
d_i in employment in low skilled industry sectors	0.208***	0.0855***	0.200***	-0.00945	-0.0083***
	(0.0250)	(0.00993)	(0.0265)	(0.0100)	(0.00221)
Constant	0.0491***	0.0714***	0.0606***	0.0700***	0.0220***
	(0.00169)	(0.00175)	(0.00284)	(0.00830)	(0.00103)
R-squared	0.333	0.143	0.207	0.000	0.006
d_i in employment in medium-low skilled industry sectors	0.0248***	0.0258***	0.0600***	0.0114*	-0.0043***
	(0.00559)	(0.00726)	(0.0156)	(0.00650)	(0.00149)
Constant	0.00363***	0.0124***	0.0155***	0.0173***	0.0138***
	(0.000295)	(0.000747)	(0.00127)	(0.00109)	(0.000609)
R-squared	0.143	0.057	0.084	0.008	0.004
d_i in employment in medium-high skilled industry sectors	0.00334***	0.00315**	0.0307***	0.000706	-0.0043***
	(0.00109)	(0.00150)	(0.0108)	(0.00362)	(0.00151)
Constant	0.00186***	0.00514***	0.0108***	0.0168***	0.0102***
	(0.000263)	(0.000513)	(0.00107)	(0.000978)	(0.000637)
R-squared	0.012	0.003	0.039	0.000	0.004
d_i in employment in high skilled industry sectors	0.000880	-5.03e-05	0.00140***	9.59e-05	-0.000884
	(0.00115)	(8.43e-05)	(0.000514)	(0.000696)	(0.000692)
Constant	0.00082***	0.00022***	0.00072***	0.00216***	0.00237***
	(0.000155)	(4.77e-05)	(0.000138)	(0.000324)	(0.000526)
R-squared	0.002	0.000	0.008	0.000	0.000

Notes: robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Furthermore, we measure to which degree the level of specialization in the secondary sector could explain the economic divergence between the resilient and non-resilient municipalities. In Table 47, we report the difference in the level of specialization – measured as the Krugman specialization index (KSI) of the manufacturing sub-sectors. Here, we find that the non-resilient municipalities were significantly higher specialized during the 1850-1930 period. Yet, this difference appears to be insignificant for the 1970 and 2010 results. As such, our results indicate that specialization in the long-run played a more important role for the decline of rust belt regions compared to high specialization on the eve of de-industrialization, in 1970.

Table 47. Estimation results for the variance between the resilient and non-resilient municipalities in the level of specialization of the manufacturing sector

	[1] 1850	[2] 1890	[3] 1930	[4] 1970	[5] 2010
d_i in KSI	0.340***	0.327***	0.243***	0.0781***	0.0378
	(0.0318)	(0.0305)	(0.0302)	(0.0238)	(0.0260)
Constant	0.766***	0.714***	0.854***	0.872***	0.865***
	(0.00837)	(0.00736)	(0.00806)	(0.00594)	(0.00694)
R-squared	0.115	0.133	0.067	0.013	0.002

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Lastly, in Table 48, we report the level of continuity, measured as the inherited industry ratio index (IIR) as developed by Nikolic (2018) in the manufacturing sub-sectors during 1850-2010. In particular, we report the continuity in the structure of the manufacturing sub-sectors for the four consecutive time periods for which we can calculate this index. Our results indicate that the non-resilient municipalities had a considerably higher continuity in their industry mix during 1850-1970. We can assume that the loss of manufacturing jobs due to de-industrialization in the last decades turned the difference in continuity insignificant for the 1970-2010 period. As such, we provide empirical evidence for the theoretical foundations of the evolutionary economic geography literature (see e.g. Boschma 2015; Martin and Sunley 2015), which stressed the importance of long-run adaptation, as our results indeed seem to indicate that the economic demise for the non-resilient municipalities during 1970-2010 was strongly associated with a continuation of their highly-specialized industry mix in the period preceding the shock of de-industrialization, during 1850-1970.

Table 48. Estimation results for the variance between the resilient and non-resilient municipalities in the continuity of the manufacturing sector

	[1] 1850-1890	[2] 1890-1930	[3] 1930-1970	[4] 1970-2010
d_i in IIR	0.107***	0.0154**	1.289***	0.356
	(0.0276)	(0.0788)	(0.248)	(0.693)
Constant	0.591***	0.948***	1.019***	0.961***
	(0.00677)	(0.0291)	(0.0378)	(0.113)
R-squared	0.019	0.013	0.071	0.001

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

5.4. Robustness checks

As a last part of our empirical analysis, we perform two counterfactual scenarios as a robustness check. First, one could argue that our results might be biased due to outliers in the non-resilient municipalities. Therefore, we exclude in our sample of non-resilient municipalities the municipalities which did not border other non-resilient municipalities, and only keep the four large clusters of non-resilient municipalities which we previously identified. This brings down the number of observations in the non-resilient municipalities from 80 municipalities to 41 municipalities: 13 in the Liège cluster, 8 in the Brussels cluster, 14 in the Charleroi cluster, and 6 in the Aalst cluster. In Table 49, we calculate again the statistical significance in variance or d_i across the resilient and non-resilient municipalities in terms of unemployment rates and average income levels. The results appear roughly the same compared to our initial results presented in Table 39. Unemployment levels and average income levels appear different between both groups prior to 2010, but the coefficient of determination reveals that only in 2010 the difference between both groups of municipalities becomes highly significant.

Table 49. Estimation results for the variance between the resilient and non-resilient municipalities in unemployment and average income levels

	[1] 1850	[2] 1890	[3] 1930	[4] 1970	[5] 2010
d_i in unemployment		0.0168***	-0.00217	0.00571**	0.0400***
		(0.00595)	(0.00169)	(0.00233)	(0.00499)
Constant		0.0184***	0.0245***	0.0241***	0.0281***
		(0.000798)	(0.000703)	(0.000479)	(0.000483)
R-squared		0.017	0.000	0.006	0.197
d_i in average income	-0.0588	-0.369***	-0.130***	0.137**	-0.238***
	(0.0525)	(0.0440)	(0.0402)	(0.0557)	(0.0228)
Constant	5.227***	5.580***	7.478***	8.762***	10.38***
	(0.0213)	(0.0270)	(0.0314)	(0.0472)	(0.00506)
R-squared	0.000	0.008	0.001	0.000	0.083

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Second, one could argue that the sample of the resilient municipalities includes not only municipalities which were able to overcome the loss of manufacturing jobs, but also municipalities which did not have many manufacturing jobs in 1970 in the first place. Therefore, we limit the observations of resilient municipalities to the municipalities for which the secondary sector took up 10% or more of the total labour force. This brings down the number of resilient municipalities from 926 municipalities to 388 municipalities. In Table 50, we re-calculate the statistical significance in variance across the resilient and non-resilient municipalities in terms of unemployment and average income levels. Here, we again find that only in 2010 the coefficient of determination reveals a statistically significant difference between the resilient and non-resilient municipalities.

Table 50. Estimation results for the variance between the resilient and non-resilient municipalities in unemployment and average income levels

	[1] 1850	[2] 1890	[3] 1930	[4] 1970	[5] 2010
d_i in unemployment		0.0155***	-0.00147	0.00647***	0.0274***
		(0.00425)	(0.00177)	(0.00193)	(0.00369)
Constant		0.0164***	0.0235***	0.0224***	0.0264***
		(0.00106)	(0.00104)	(0.000674)	(0.000724)
R-squared		0.055	0.001	0.030	0.235
d_i in average income	-0.153**	-0.330***	-8.08e-05	0.366***	-0.145***
	(0.0669)	(0.0803)	(0.110)	(0.117)	(0.0228)
Constant	5.267***	5.656***	7.571***	8.561***	10.39***
	(0.0362)	(0.0466)	(0.0506)	(0.0665)	(0.00748)
R-squared	0.007	0.020	0.000	0.012	0.109

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

6.6. Conclusion: consequences of de-industrialization

In the previous sections, we aimed to confront the literature on rust belt regions with empirical evidence on de-industrialization in the Netherlands and Belgium during 1850-2010. Most of the literature on this topic follows a predefined notion of rust belt regions, based on a region's present-day economic performance or share of manufacturing jobs in the past (e.g. Grabher 1993; Franck and Galor 2017). We introduce an unbiased classification strategy to distinguish between regions that were resilient against de-industrialization during 1970-2010 and the regions that were not, by drawing on an automatic switching regression model and a large panel dataset. With this model, we distinguish between the regions that were affected in their unemployment rate in 2010 by the loss of manufacturing jobs during 1970-2010, and the regions which were not. We deploy this model on a large panel dataset for all municipalities in the Netherlands and Belgium, of which the latter country houses a notorious rust belt region located between the cities of Mons and Liège, making these regions an excellent case study to explore the economic origins of rust belts. Our aim was twofold: first, identifying the regions which were not resilient against de-industrialization and second studying the differences between resilient and non-resilient municipalities in the 1850-2010 period.

The model reveals that in most Belgian and Dutch municipalities unemployment levels in 2010 are not associated with the loss of manufacturing jobs during 1970-2010, indicating that for most regions the negative effects of de-industrialization were sufficiently compensated by existing mechanisms of redistribution. Yet, for roughly one tenth of all municipalities, the loss of manufacturing jobs during 1970-2010 is associated with an above average unemployment rate in 2010. Our evidence shows that most of these non-resilient municipalities were located in the region acknowledged as the Belgian rust belt, though other areas in Belgium and the Netherlands experienced a similar fate. For these municipalities, a reversal of fortune seems to have occurred during 1970-2010, whereas no signs of economic depravity are found for the pre-1970 period. In particular, we find that no significant differences between the resilient and non-resilient municipalities existed in the 1850-1970 period in terms of average income levels, unemployment rates, or public investment. For human capital, although we find that the non-resilient municipalities had an on average higher illiteracy rate during the 1850-1930 period, in line with the findings of Franck and Galor (2017) for France, these differences in human capital endowment are found to become statistically insignificant during the twentieth century.

Yet, our evidence indicates a significant difference between the resilient and non-resilient municipalities in their economic structure during 1850-2010, thereby empirically confirming the relevance of concepts such as slow-burn processes of related and unrelated variety, or adaptation and adaptability, in the field of evolutionary economic geography (e.g. Boschma 2015; Martin and Sunley 2015). In particular, we find that the non-resilient municipalities had a substantial higher share of employment in the secondary sector, most notably low-skilled industry jobs, during the 1850-1930 period. In addition, our results indicate a significant difference in adaptation and specialisation in the structure of the manufacturing sector throughout the 1850-1970 period between both groups of municipalities. As such, we find support for the studies which argued that present-day rust belt regions had a highly specialized industry mix (Hobor 2016; Martin et al. 2016; Brown and Greenbaum 2017), dominated by predominantly low-skilled industry sectors (Martin 2012; Diodato and Weterings 2015), which made these regions less equipped with the necessary tools to overcome the loss of manufacturing jobs in the last decades.

Chapter 7. Conclusion

7.1. The location of industry in the Low Countries: a restatement

Ever since Adam Smith (1776) brought forward the question why some countries are rich and others less, spatial patterns of economic growth and inequality have been a topic of debate. Economic history has contributed to this debate, in which the general consensus is that the differences in economic growth and inequality across countries are the result of a long-term evolution that can be traced back to the start of the Industrial Revolution at the end of the eighteenth century. To a large extent, the differences in the timing and extent in the pursuit of modern economic growth during the nineteenth and twentieth century are able to explain present-day differences in economic growth across countries. Yet, whereas this path to modern economic growth has been different across countries, even within countries substantial differences have emerged, as the North-South divide in the United States, Britain, or Italy testify. For long, countries have been the standard unit of analysis in historical research in studying economic development, whereas the regional dimension has gained only recently increasing attention in economic history research (e.g. Crafts and Mulatu 2005; Combes et al. 2011; Wolf and Roses 2018). This PhD thesis aims to contribute to our understanding of spatial patterns of economic development, by offering an empirical investigation on the location of industry in the Netherlands and Belgium during the nineteenth and twentieth century. This thesis has explored the patterns of regional industrialization and the determinants behind these patterns in the Low Countries during four episodes of continuity and change: the transition from proto-industry to modern industry, the transition during the first and second Industrial Revolution, the transition during the twentieth century, and the transition during de-industrialization.

After a brief introduction in the first chapter, we continued in the second chapter with the long-run trends in the location of industry in the Netherlands and Belgium. Here, we contribute to the historiography in the Low Countries, by overviewing the regional trends in the location of industry during the 1820-2010 period, drawn from data of the Belgian and Dutch population and industry censuses. Whereas the contrasting experience of Belgium becoming the second country to experience an Industrial Revolution and the Netherlands an industrial lagger has frequently been highlighted, we find that most of the Belgian lead can be attributed to the exponential rise of industrial activity alongside the Liège-Mons axis, far surpassing the other Dutch and Belgian regions. During the second phase of industrialization, when industry clustered near centres of consumer markets and transport facilities, new industries emerged disproportionally around urbanized centres, an evolution of which the Dutch northern and the Belgian southern regions were less able to benefit from. When both countries entered the post-industrial phase during the second half of the 20th century, the Dutch eastern and Belgian southern regions were less able to compensate the disappearance of their industry base, shaping to a large extent the current economic geography in both countries. Throughout the 1820s-2010s, both countries faced structural changes in their industry mix and spatial distribution of economic activities. Regional specialization in industry is found to have increased in both countries during the 1820s-1930s, followed by a stabilization during the 1930s-1970s and subsequent decline in recent times. In contrast, the level of path dependence in industry declined throughout the nineteenth and twentieth centuries.

Chapter three has put forward an empirical test of the literature on proto-industrialization (e.g. Mendels 1972; Kriedte, Medick, and Schlumbohm 1981; Ogilvie and Cerman 1996), by exploring the effect of proto-industrialization on industrialization during the Industrial Revolution in Belgium and the Netherlands. Using the division between proto-industrial and modern industrial employment in historical census data, we explore the cross-municipal variation in employment in proto-industrial and industrial activities in textiles production in the two largest textiles-producing regions in the Netherlands and Belgium: respectively the Eastern Netherlands and Flanders. We test for the correlation between demographic, geographic, and institutional characteristics, where we find that proto-industrial and industrial activities had different locational pull factors. We find evidence for a positive significant effect of proto-industrial activities on modern industry in the Eastern Netherlands but an insignificant effect for Flanders, due to differences between both regions in the access to labor and consumer markets, as well as a different organization of proto-industrial production. In Flanders, in contrast to Mendels (1972), we find that many proto-industrial families long preferred to supplement their proto-industrial income with other part-time sources of income, rather than taking up a full-time factory job. In contrast, we find for the Eastern Netherlands a positive significant effect, as industry seems to follow largely the proto-industrial heartland. Here, we find that entrepreneurs in their search for labourers in this labour-scarce area moved to the countryside, an evolution of which the active industrial policy of the *Nederlandse Handelsmaatschappij* (or Dutch Trading Society) played an important role. This diverse effect highlights the ambiguous role that proto-industrialization played for the location of industry.

Chapter four traces the causes of the Industrial Revolution in Belgium and the Netherlands during the nineteenth century in a comparative perspective. In the literature, human capital is considered an important driver of industrialization. Yet, isolating its importance during the Industrial Revolution has proven difficult. In this chapter, we test for the effect of human capital on industrialization during the first and second half of the nineteenth century. We find that human capital indeed affected industrialization in both countries, though in contrasting ways. We find a negative effect of human capital during the first Industrial Revolution, with predominantly low-skill intensive industries emerging near regions with an illiterate and cheap labour force. As such, our evidence compliments the historiography which stresses the role of the relative high illiteracy rates and the low wage rate in Belgium to explain the Belgian lead in the Industrial Revolution compared to its northern neighbour. Yet, in addition, we find that this evolution was responsible for intra-country geographical shifts as well: with in Belgium, the south benefitting at the expense of the north and in the Netherlands, the peripheral eastern and southern regions benefitting more than the Dutch west. For the second phase of industrialization, we find a contrasting evolution, with high-skill intensive industries emerging near regions with high stocks of human capital, causing a convergence between the Netherlands and Belgium. This evolution indebted a regional divergence as well, with the Holland region in the Netherlands and the northern provinces in Belgium seeing the highest rise in skill-intensive industries during the second half of the nineteenth century.

In chapter five, we analyse the determinants of industrial location in the Netherlands and Belgium in the 19th and 20th century. To this end, we use a new dataset based on population and industrial censuses with homogeneous data for the two countries on regional and industrial characteristics at a detailed geographical and sectoral level in 1850, 1890, 1930, 1970, and 2010. Industrial location is analysed in the framework of Midelfart-Knarvik et al. (2000), where the geographical distribution of industry is explained by the correlation between regional and industrial characteristics, respectively belonging to the Heckscher-Ohlin category of determinants (factor endowments) or the New Economic Geography category (market potential). Previous historical studies using the Midelfart-Knarvik et al. (2000) model indicated non-negligible variability between countries and periods regarding the significance and the weight of the determinants included (e.g. Crafts and Mulatu 2004; Wolf 2007; Martinez-Galaraga 2012; Klein and Crafts 2012; Missiaia 2017; Nikolic 2018). Besides the consensus that both factor endowments and market potential seem to matter for the location of industry and that the first declined and the latter increased in weight since the 19th century, not much has been concluded regarding the relative importance and the impact of the two categories of determinants. By using homogeneous data at a detailed sectoral and geographical level, we are able to study both across and within country variation in the determinants of industrial location in a setting of early and late industrializing regions with strongly contrasting evolutions in economic development. Our evidence points to a shift within both categories of determinants over the twentieth century. Whereas for the Heckscher-Ohlin category of determinants a shift occurred from labour and agricultural inputs to human capital, the New Economic Geography category of determinants from market potential effects through size of industry to sales and intermediate goods. We find significant evidence for regional disparities in both countries. In the Netherlands, we find that both New Economic Geography and Heckscher-Ohlin determinants can explain the location of industry in the populous Western regions, due to the market access via the ports of Rotterdam and Amsterdam, whereas the more 'peripheral' eastern, northern and southern regions only Heckscher-Ohlin determinants appear significant. Similarly, we find for Belgium that for the northern region of Flanders, with access to international markets via the port of Antwerp and a larger domestic market, both Heckscher-Ohlin and New Economic Geography determinants play, whereas in the land-locked Wallonia region only Heckscher-Ohlin determinants. As such, our results suggest an explanation for the relative higher disappearance of manufacturing jobs in both Wallonia and the peripheral Dutch regions after the 1960s.

Chapter six focuses on the effects of long-term industrialization on the resilience against de-industrialization. Although the Industrial Revolution is considered to have been a catalyst of economic growth, research on so-called rust belt regions indicates that many once-thriving industrial regions have struggled during the last decades in the face of de-industrialization. In order to identify the long-run causes of resilience against de-industrialization, in this chapter, we set out to study systematically which regions in the Netherlands and Belgium have experienced a negative effect of de-industrialization during 1970-2010 and how these regions differed in terms of economic growth during the 1850-2010 period. Therefore, we deploy a self-automatic switching model to distribute the municipalities in Belgium and the Netherlands in two groups: the municipalities which proved resilient against de-industrialization during 1970-2010 and the municipalities that were not. We find that about one tenth of the municipalities could be identified as non-resilient, mainly but not exclusively located near the

Belgian rust belt of the Mons-Liège axis. Further analysis reveals that for these non-resilient municipalities, an economic reversal occurred during 1970-2010, but did not differ from the resilient municipalities in average income levels, unemployment rates, or public investment during 1850-1970. Yet, we find evidence that the non-resilient municipalities had a consistent higher share of employment in the secondary sector during 1850-1970, especially low-skilled industry sectors, in addition to a higher level of specialization and economic continuity in the secondary sector, indicating that a long-run specialization in industry limited the capabilities of these regions to adapt and recover when jobs in manufacturing disappeared during the second half of the twentieth century.

7.2. The determinants of industrial location: an evolutionary perspective

The presented evidence on the Netherlands and Belgium allows us to reflect upon the classical theories of industrialization as presented by Polanyi (1944), Kuznets (1955), Rostow (1960), Landes (1960), Gerschenkron (1962) and Bairoch (1963). These theories presented a linear and national perspective on industrialization, a view which has remained dominant in many narratives on long-run industrialization until present. In this perspective, countries transcended to an Industrial Revolution and subsequently passed through different phases of industrialization, in which each phase was pushed by different factors of industrial growth. Often, these phases were presented as a fairly homogenous process, in which countries either underwent a similar process over time across countries (Polanyi 1944; Kuznets 1955; Rostow 1960; Landes 1960), or groups of countries, with differences between early and late industrializers (Gerschenkron 1962), or differences between developed and developing countries (Bairoch 1963). As one of the first to oppose such a linear, national view on industrialization, the seminal work of Pollard (1981: VII) argued against the "almost axiomatic assumption of Gerschenkron, Kuznets and others that countries within their political boundaries are the only units within which it is worthwhile to consider the process of industrialisation. It is a major premise of this study that this process, on the contrary, is essentially one of regions".

In the last decades, this statement of Pollard (1981) has pushed studies in economic geography and economic history to reconsider the linear, national view of these classical theories of industrialization. In the last decades, economic geography studies, critiquing the national view, have informed us on the factors that can explain local economic growth and how intra-country differences can become just as large as inter-country differences (e.g. Krugman & Venables 1995; Redding & Venables 2004). In addition, new economic history studies, critiquing the linear view, have contributed to our understanding on how these factors of local economic growth change over time and that some region's initial conditions might reinforce or reverse the economic potential of a region (e.g. Betran 2011; Crafts & Wolf 2013). Yet, no alternative view on long-run industrialization, which combines these recent lines of research in new economic history and economic geography, has been developed as a systematic answer to the classical theories of industrialization as put forward by Polanyi (1944), Kuznets (1955), Rostow (1960), Landes (1960), Gerschenkron (1962) and Bairoch (1963). Much in line with the studies in new economic history and economic geography, the evidence presented in this manuscript has grown from the ambition to offer such a systematic reformulation of the classical theories of industrialization.

As a systematic alternative to these classical theories of industrialization, we put forward a more dynamical, evolutionary perspective on industrialization, in which each phase of industrialization (presented with changes in technological advancements, demand for inputs, and energy sources) favoured different determinants of industrial location, but yet the new industrial activities co-existed together with former accumulated industries, as the former determinants of industry and former accumulated industrial activities were able to strengthen or weaken the capabilities to benefit from these determinants of industrialization. In line with this evolutionary view on industrialization, we put forward five statements.

First, the location of industry during the nineteenth and twentieth century can largely be explained by factor endowments, market potential, and institutions. Yet, within these categories, each phase of industrialization favoured different locational determinants. In the early nineteenth century, a period presented with high transport costs, industries favoured locations with a proximity to labour and natural resources. Subsequently, the mechanization of a limited number of industry sectors during the Industrial Revolution increasingly favoured locations with a cheap and less-skilled labour force and the availability of a particular energy source: coal. The second half of the nineteenth century saw the rapid development of a more diversified pallet of capital-intensive industries, industries which benefitted increasingly from economics of scale, and led to the emergence of the so-called technology-skill complementary at the end of the nineteenth century. As a result, the second phase of industrialization favoured locations with a skilled, educated labour force and regions with a proximity to international and national markets. After the Interbellum, the exponential rise in technology, the advancement of oil as a major energy source and the rise in international trade accelerated the relevance of market potential, to reap the benefits accruing from agglomeration effects, and knowledge clusters, to keep up with innovation that continues to grow on an unprecedented scale.

Second, notwithstanding these changes in the determinants of industrial location, many of these determinants continued to exert a role for the location of industry, with often only the relative importance of each determinant increasing or decreasing over time. So, despite the fall in transport costs over time, we found that the agricultural inputs continued to play a role for the location of industry in the Netherlands and Belgium, most notably in the northern and eastern regions in the Netherlands. Indeed, many determinants have continued to exert an influence on the location of industry, though often in varying degrees. Human capital came on the forefront during the transition from the first Industrial Revolution, which favoured regions with illiterate and cheap labourers, to the second phase of industrialization, which favoured a skilled labour force. Yet, during the twentieth century, the increase of technology and innovation increased the relevance of a smaller, higher-educated population group, at the expense of the skills of the general labour force. A similar change took place for the role of market potential. In the age of the Industrial Revolution, industries clustered in places with access to international and domestic markets, in particular the industries with few bulk inputs that produced consumer goods. With the fall of transport costs, initially most notably large-scale industries favoured locations with high values of market potential. Yet, the twentieth century introduced a period in which agglomeration benefits pushed increasingly industries with a similar use of intermediate goods and sales to industry close to regions with high market potential.

Third, these determinants of industry not only presented themselves with a great variability over countries, but also over regions. The earlier take-off of the Industrial Revolution in Belgium has granted the country the title of the first industrialiser on the European continent, whereas the Netherlands became known as a relative latecomer in industrialization. Amongst other explanations, the availability of coal reserves in Belgium - with the Netherlands having no such resources - has rightfully become an influential explanation for this difference. Yet, these natural resources were confined to a small region within Belgium, and the number of installed steam engines in the Dutch regions appeared largely on the same level compared to the Belgian regions which were not equipped with coal reserves. Likewise, our study finds that often particular regions in the Netherlands and Belgium share more communalities in the determinants of industrial location as some of their regional counterparts within the same country. For instance, the Antwerp region in Belgium and the Holland region in the Netherlands benefitted similarly from the pull-effect of market potential during the second phase of industrialization, whereas other regions in both countries were less capable to reap the pull-effects accruing from market potential in this period of time. Similarly, having the same regional characteristics did not necessarily translate in similar patterns of industrialization: whereas the countryside in Flanders and the Eastern Netherlands shared many common regional characteristics and held a widespread proto-industrial production on the eve of the Industrial Revolution, both regions experienced in a very divergent fashion the transition from proto-industrialization into the Industrial Revolution.

Fourth, pre-existing industrial activities played a considerable role, with new industrial activities being either attracted by pre-existing industrial activities or developing as a spin-off industry from pre-existing branches of industry. Our evidence on path dependence implicates that the existing industrial structure affected the capabilities to develop new industrial activities. Here, even the age of the Industrial Revolution, widely considered to be a major shock to the location of industry, seems to have built in many regions upon the pre-industrial or proto-industrial past. Considering the long-run trends throughout the nineteenth and twentieth century, our evidence indicated that the impact of path dependence declined over time, but nonetheless remained existent until present. Most notably, our evidence finds that path dependence through the sunk cost mechanism declined in importance over time: the fall of transport costs and increase in market integration increased the mobility of industrial firms, and therefore removed many costs related to relocation. Yet, path dependence through increasing returns mechanisms remained in place, with many firms ensuring the continuity in the location of industry through agglomeration effects.

Moreover, the extent of regional specialization, or the extent upon which these determinants have shaped the economic geography within the Low Countries, changed considerably over time. At the beginning of the nineteenth century, regions were endowed very differently in terms of factor endowments, market potential and institutions. Consequently, regions faced very different capabilities to develop industries. Yet, high transport costs imposed a limit on regional specialization, and therefore spatial inequalities. Throughout the nineteenth century and the beginning of the twentieth century, transportation costs declined and market integration increased, and therefore removed many limits on regional specialization. As a result, differences in the determinants of industry increased the spatial concentration of industry, and subsequently increased inequality across regions. Subsequently, throughout the twentieth century, the rapid boom in car transportation and communication technology implicated a compression in the distance between regions. As a result, differences in regional specialization in industry and income levels started to decline as well. Thus, not only did the determinants of industry change throughout the nineteenth and twentieth century, but also the extent upon which the determinants of industry could affect the height of spatial inequalities in both countries seems to have changed over time.

7.3. Limitations and avenues of further research

The main goal of our endeavour has been to explore the main trends in the determinants of industrial location during the nineteenth and twentieth century, by following the location of industry in the Netherlands and Belgium. For answering this research question in a cohesive manner, we had to focus on theories from the field of economic history. As regards to new economic geography, the theories relating to market access and economics of agglomeration have been mentioned in this study, but nonetheless could further be explored. For instance, in the sixth chapter, we constructed highly-disaggregated estimates of market potential, which could potentially contribute to a better understanding of agglomeration economics. In addition, combined with data on transport networks, such datasets could contribute to the literature that studied the effect of transport revolutions, such as the rise and subsequent demise of railroad transport and the rise of car transport. For the field of evolutionary economic geography, which made path dependence and history central to much of their work, the provided insights would be able to expand our knowledge on the extent and causes of path dependence in regional economic structures.

In addition, it could rightfully be pointed out that in our search for the locational determinants of industry throughout the last two centuries, we have drawn methodologically almost exclusively upon quantitative evidence and a rigorous econometric framework. Therefore, this study explored only limited qualitative and micro-economic evidence. Yet, we believe that the presented larger evolutions offer potential insights for the research on individual business or consumer behaviour, in particular for the field of business history. For instance, whereas our evidence points out that factories shifted from cheap and low-human capital intensive labour to a high-wage and high skilled labour force during the transition from the Industrial Revolution to the second phase of industrialization, we can hypothesize how this trade-off varied over specific market conditions, which differed from company to company. Yet, as we consider this study a first – though necessary – step in distilling larger evolutions, we hope that future studies can benefit from this study to expand our knowledge on such micro-economic patterns.

Third, although the regional dimension has been a core focus of this study, we limited ourselves in this manuscript predominantly to aggregate regional patterns, on the NUTS1 or NUTS2 level. Yet, as our evidence has shown that the determinants of industry differ over these larger macro-regions, we believe that even within these macro-regions notable differences can arise to the surface. For instance, one dimension that has played a less explicit role, but certainly is close to the surface in this manuscript, are urban-rural differences. In chapter five, we have shown how market potential and human capital increasingly came to drive the location of industry throughout the twentieth century, at the expense of locational determinants such as the proximity to natural resources and agricultural inputs. Since the first two factors could predominantly be found in cities and the latter could predominantly been found in rural areas, this evolution would have presumably indebted a shift from the countryside to larger cities. Yet, this hypothesis remains untested. Therefore, all in all, we hope that the larger evolutions presented in this thesis can stimulate further research on this topic to contribute to our understanding of the economic landscape in both countries.

7.4. Implications for research and policy

We can categorize three lines of implications of this study. First, regional inequality has attracted considerable attention in the last decades. Just as the Industrial Revolution and its aftermath has widely been credited a considerable role for explaining divergence across countries, so should regional industrialization and de-industrialization be recognized as a major explanation of spatial disparities in economic growth and inequality. For instance, the reversal of fortune that the Great Lakes region in the USA, the Midlands in the UK, the Ruhr area in Germany, and the Nord-Pas-de-Calais region in France experienced throughout the past centuries are well-documented. Studies often neglect the long-run history of these regions, while economic history could offer not only insight in the origins and development of the reversal of fortune that these regions experienced, but might even contribute to debates about devising an escape route out of economic depravity for these areas. The presented evidence in this study documents how the change in the determinants of industry introduced for some regions a period of economic fortune, but economic hardship for other regions at the same time. As the transition from proto-industry to modern industry offered during the nineteenth century an economic opportunity for proto-industrial producers living in regions with an access to consumer markets, similarly the disappearance of jobs in manufacturing during the post-war period limited the capabilities for a small though considerable number of municipalities in the Low Countries. All in all, these cases highlight the necessity of well-directed policy to balance between inter-regional economic solidarity, whilst not hampering the benefits accruing from economics of scale and agglomeration.

In addition, the study has stressed the importance of intra-country differences in industrial determinants. We presented a great deal of evidence on how, even during brief periods of time or across closely located regions, the determinants of industrial location could differ considerably. For instance, in chapter three, we revealed how in the Eastern Netherlands the presence of proto-industrial activities was a successful preparation for modern factories during the nineteenth century, whereas this was a relative failure in Flanders. Similarly, in the fifth chapter, we find how the determinants of industrial location in the twentieth century differed considerably between Flanders and Wallonia in Belgium on the one hand and the Western regions compared to the other regions in the Netherlands on the other hand. Consequentially, it is fair to say that industrial policy should consider more the regional perspective, as the pull –and push-factors to stimulate the establishment of the industries of the future differ gravely across regions. As the strengths and weaknesses of regions often are path-dependent and trace back further in time than one might consider at first sight, the presented evidence could help in identifying a region's strengths and weaknesses. Indeed, our evidence could offer a valuable tool for different levels of government and local actors in identifying the reasons why old industrial activities will re-locate in the future, but also to assess which pull- and push-factors can be exploited the most for attracting new economic activities.

Third and foremost, our evidence points to the relevance of diversification and renewal in the economic structure to make regions resilient in the long-run. As the locational determinants of industrial activities change over time, policy should not rely overtly on economic activities of the past and present, but rather critically assess the trade-off between maintaining old activities and attracting new economic activities. Both the case of proto-industrialization in nineteenth century Flanders – where proto-industrial producers on the countryside continued to produce with old-fashioned production methods against the face of the first Industrial Revolution – and post-war Wallonia – where government funds were used for infrastructure investments in the already declining sector of metallurgy – are exemplary, with both regions undergoing economic decline due to the lack of diversification and renewal. The development of new industrial activities is strongly embedded in territorial capabilities, of which a region's industrial past conditions the local capabilities to develop new economic activities. As we have quantified systematically the economic structure of the regions in the Netherlands and Belgium in the long-run in this study, we offer an instrument for further research on related and unrelated variety, which quantifies the probability of a region to attract new industries based on pre-existing industries in a region (e.g. Neffke, Henning and Boschma 2011). At present, most studies on related and unrelated variety have drawn from data of the second half of the twentieth century. Yet, this short-term perspective might not be ideally suited, as drawing from data for this short period features a period in which creative destruction and technological change has been more stable compared to the long run. Therefore, it is our hope that this manuscript might offer new insights in how industries can spin-off in new industries, and how regions are able to develop new activities based on re-branching existing industries.

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Appendices

Appendix A. Methodological notes on the 1820-1890 industry censuses

As mentioned in section 1.4., we have drawn predominantly from the industry censuses in both countries to reconstruct the number of employees, establishments, and value of fixed-asset capital stock. For Belgium, we can rely on the 1846, 1896, 1937 edition of the census of industry. For the Netherlands, we can rely on the 1930 and 1978 edition of the census of companies. For 1820, we digitized an industry census conducted under the United Kingdom of the Netherlands (1815-1839) which encapsulated grossly present-day Belgium, the Netherlands, and Luxembourg. For 1850 in the Netherlands, we turned to the 1859 Condition of the Dutch factories (Nederlandse Maatschappij 1859), and for 1896 a large collection of municipal reports (Philips 2019). For 2010 in the Netherlands, we turned to the LISA dataset, which de facto encapsulates all private establishments in industry in the Netherlands. For 2010 in Belgium, we turned to two collections of statistical series measured by the Belgian offices of social security: the RSZ statistics and the RIZIV statistics, the first measuring all employees who are registered for the social security office and the second measuring all employers who are registered for social security office. Combined, de facto, both statistical series measure the entire labour force in industry in Belgium.

Combined, these industry censuses make it possible to estimate the number of establishments and the number of employees for each ISIC sector at the NUTS2 (province) level in the Netherlands and Belgium for the 1820-1890 period. In addition, for the 1890-2010 period, the data can be broken down to the LAU2 (municipal) level. Additionally, we can estimate the number of steam engines and steam boilers for the 1820-1930 period. As argued in section 1.4., the industry censuses of 1930, 1970, and 2010 paint a fairly representative image of the number of employees and establishments in industry in Belgium and the Netherlands. Yet, for the 1820, 1850, and 1890 censuses, the historiography has argued against this. Therefore, in the next sections, we discuss in detail how we account for these issues and used these sources to construct a representative database, a process in which we in particular relied on the method of using the population census to correct the under –and overvaluation of the industry censuses.

A.1. Belgian-Dutch industry census of 1819

For the industrial employment data of 1820, we used the published data series of Brugmans (1956), which digitized the industrial census of the former Dutch and Belgian United Kingdom of the Netherlands, conducted on the 31th of December 1819. A first issue with this industry census concerned the provincial boundaries when the census was constructed. As seen in Figure 1, the boundaries of the provinces at the time of the census differed considerably from their counterparts in the Kingdom of the Netherlands and the Kingdom of Belgium in 1850. While the province of Limburg was a single province in 1819, after the Belgian Revolution the province was split in a Dutch and a Belgian part. Therefore, the province had to be divided in these two parts for our study.[81] Similarly, the 1819 province of Luxembourg was divided in two parts: one part which developed into the kingdom of Luxembourg and one part which developed in the Belgian province of Luxembourg. Lastly, smaller changes in the provincial boundaries occurred, most notably in the provinces of Utrecht, Overijssel, and Liège. To correct the employment numbers for these provinces, we used the differences in provincial surface between 1820 and 1850 to downsize or elevate the number of employees in these provinces.

Figure 1. Difference in province boundaries between the United Kingdom of the Netherlands and the Kingdoms of the Netherlands and Belgium in 1850

[81] Since the province of Limburg was divided between the Dutch and Belgian government, we faced a methodological problem. The combined surface in 1850 was 4 590 km^2, with the Dutch part encompassing 2 176 km^2 and the Belgian part 2 414 km^2. Keeping mind that the combined province in 1820 measured 4 542 km^2, we use the former distribution to measure the Dutch (2 153 km^2) and Belgian part (2 389 km^2) in 1820.

A second obstacle concerned the calculation of the number of employees. The census measured separately the number of child employees and adult employees. So, the census takers were directed by the national government to provide a count of child employees, as no previous census had been undertaken to measure their occurrence. Yet, as there is no clear definition of what age group the census takers used to distinguish between child and adult employees, we made the sum of the total adult and child workers to derive the number of employees. Additionally, since the census excludes the owner of the company from the employment statistics, we added the total number of establishments to the number of employees.

Third, an additional estimation had to be made concerning the province of North Holland. As Brugmans (1956: XXIV) pointed out, the census reported not a single employee in bakeries, glass blowers, smiths, book binders, and other widely considered conventional professions in this province. Dansma, De Meere and Noordegraaf (1979: XIII) pointed out that the provincial executives (or *Gedeputeerde Staten*) of North Holland assumed that the national government was only interested in the enterprises which were under the 1816 Law of Tarrifs (or *Tariefwet*). Additionally, we can assume that the provincial government of North Holland saw in this line of argumentation an escape route out of this costly operation. To interpolate the missing numbers in this province, we devised a two-step method. First, we had to identify the industry sectors for which the province of North Holland did not report the employment numbers. For this, we selected those sectors for which in all provinces at least one employee was found, based on which 28 industry sectors could be identified that did not report the number of establishments and employees in North Holland.[82] Second, we had to estimate the number of establishments and employees in these sectors in the province of North Holland. Based on the census data of these particular manufacturing sectors in the surrounding provinces of Utrecht and South Holland, we estimated the average per capita number of establishments and employees in each of the missing industry sectors. Using the population number of North

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[82] In particular, this concerned the following industry sectors: paperhangers (or *behangerijen*), broom makers (or *bezemmakerijen*), bookbinders (or *boekbinderijen*), brush binders (or *borstelmakerijen*), bread bakers (or *broodbakkerijen*), turners (or *draayerijen*), glass blowers (or *glasblazerijen*), glass makers (or *glazenmakerijen*), harness makers (or *haam -en gareelmakerijen*), farriers (or *hoefsmederijen*), chandlers (or *kaarsenmakerijen*), tailors (or *kleermakerijen*), small-smiths (or *kleinsmederijen*), clogmakers (or *klompenmakerijen*), cake or biscuit makers (or *koekbakkerijen*), flour mills (or *korenmolens*), coopers (or *kuiperijen*), slaters (or *leidekkerijen*), plumbers (or *loodgieterijen*), basket makers (or *mandenmakerijen*), masons (or *metselarijen*), makers of fashion goods (or *modegoedmakerijen*), sewers (or *naaiwinkels*), tan mills (or *runmolens*), locksmiths (or *slotenmakerijen*), chair makers (or *stoelenmakerijen*), tinsmiths (or *tinnegieterijen*), oil painters (or *olieverwerijen*).

Holland around that time, next we multiplied the per capita number of establishments and employees.[83]

Fourth, both the original census records of 1819 as well as the edition of Brugmans (1956) suffered from missing and incomplete observations. For instance, Brugmans (1956) noted that the original census records often mistakenly took over numbers from other columns. So, equal the number of establishments for the fencing foils factories (or *fleuretfabrijken*) and velvet factories (or *fluweelfabrijken*) in the province of Antwerp the number of employees, similar as the number of establishments and employees for the glass blowers (or *glasblazerijen*) and glass cutters (or *glassnijderijen*) in the province of Namur. Similarly, observations were not always complete, in both the original census and its reformulation by Brugmans (1956). In the number of establishments and employees, we come across original formulations such as "not able to determine" ("niet te bepalen"), "undetermined" (or "onbepaald"), "only for recreational use" (or "slechts liefhebberij"), "not included" (or "niet opgegeven"), "without" (or "zonder"), cells indicated with an "-", or simply empty cells. We corrected for these missing values in the following manner. In case the number of employees or the number of factories were incomplete, we used the average national number of employees per establishment or the average national number of establishments per employee. For the cases where both the number of establishments and employees were missing, we used the average per capita number of the factories and employees of the surrounding provinces, which we subsequently multiplied with the population number of the missing province.[84]

Lastly, we used the occupational structure of the population census to assess the representativeness of the industry census. For the Netherlands, we can turn to the occupational structure as estimated from the population census of 1807 and 1811 by Van Zanden (1986). Based on these sources, Van Zanden (1986) estimated the employment in industry – excluding

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[83] According to the population census on the 31st December of 1824, North Holland counted 393,916 inhabitants (on a total of 6,013,478 inhabitants in the United Kingdom of the Netherlands). For the other cases where we had to estimate population to construct this census, we used the same population census.

[84] For the province of North Holland, we used the provinces of South Holland and Utrecht. For the province of Namur, we used the provinces of Luxembourg, Liège and Hainaut. For the province of Zeeland, we used the provinces of North Brabant, Antwerp and East Flanders. For the province of Drenthe, we used the provinces of Groningen, Friesland and Overijssel. For the province of Hainaut, we used the provinces of Namur, South Brabant and Liège. For the province of Liège, we used the provinces of Hainaut, Luxembourg and South Brabant. For the province of Utrecht, we used the provinces of North Holland, South Holland and Gelderland. For the province of Friesland, we used the provinces of Groningen, Drenthe and Overijssel. For the province of Overijssel, we used the provinces of Gelderland and Drenthe. And lastly for the province of Luxembourg, we used the provinces of Namur and Liège.

the building and construction sector but including the mining and manufacturing sectors – in the Netherlands on 169,466 employees. In comparison, our estimated total of 178,518 employees indicates that the industry census captured the employment in the industry sector relatively well. So, we can argue that the population increase in the Netherlands, from 2,201,000 citizens in 1811 to 2,354,000 citizens in 1820 (CBS 2001), can largely be credited for the difference between both numbers. Yet, for Belgium, we face a lack of an estimation of the Belgian labour force around 1820. So, did Buyst (2018) use the employment numbers of the same industry census for his reconstruction of the Belgian labour force in the industry sector. Yet, considering that the numbers for the Dutch provinces were representative, we follow Buyst (2018) in his assumption that the estimated 441,944 employees in industry in Belgium from our reconstruction are a representative count of the total labour force in industry.

A.2. Belgian industry census of 1846

For the estimation of the industry sector in Belgium around 1850, we turned to the first industry census conducted in Belgium, on 15 October 1846. Often, this source has been credited by historians as untrustworthy, for which they mainly pointed to four reasons.

First and of most importance, domestic manufacturing activities were excluded in this census (Census 1846: VIII). This flowed from the assumption among the census takers that by including domestic workers, many domestic workers would be recounted, as domestic workers often had multiple occupations or worked for multiple contractors (Bracke 2000: 185). Often, previous studies have minimized the importance of the domestic industry, given the low productivity and part-time employment in this sector. For instance, De Brabander (1984: 56) noted that “from an economic point of view this group [referring to the domestic textiles and apparel workers] is not too important: home-working was in almost every case a complementary job”. Yet, as argued by Buyst (2007, 2018), domestic manufacturing encapsulated a large employment share in industry until deep into the nineteenth century. Indeed, when for instance, turning to the 1896 Belgian industry census, the provinces of East-Flanders and West-Flanders alone counted 43,671 employees occupied with domestic spinning.

Second, the census intended to report the ‘average’ number of employees working on the 15th of October 1846 (Census 1846: LX), which was problematic as it was unclear what this ‘average’ actually measured. As De Brabander (1984: 43) noted, it remains unclear whether the census accounted for seasonal changes, temporary lay-offs, or occasional activities, such as people only working on a limited number of days. Kruithof (1957: 226) argued that this could be credited to intentional fraud, as entrepreneurs reported low employment numbers to avoid taxes, whereas Hannes (1975: 19) argued that the vaguely, ill-constructed questions in the census questionnaire were to blame. More systematically, fiscal reasons are argued to have incentivized entrepreneurs to declare a lower number of workers, a fear which existed among the census reporters of 1846 (Census 1846: XVI), but is argued to have impacted industry censuses until the beginning of the twentieth century (Census 1910, vol. I, LXXVII; De Brabander 1984; Buyst 2007; Bracke 2008). Additionally, the timing of the census was also problematic, as it registered employment at a moment when the agricultural crisis led to a temporary high level of unemployment (Census 1846: XIII-XVI; De Brabander 1984: 47; Buyst 2007: 6).

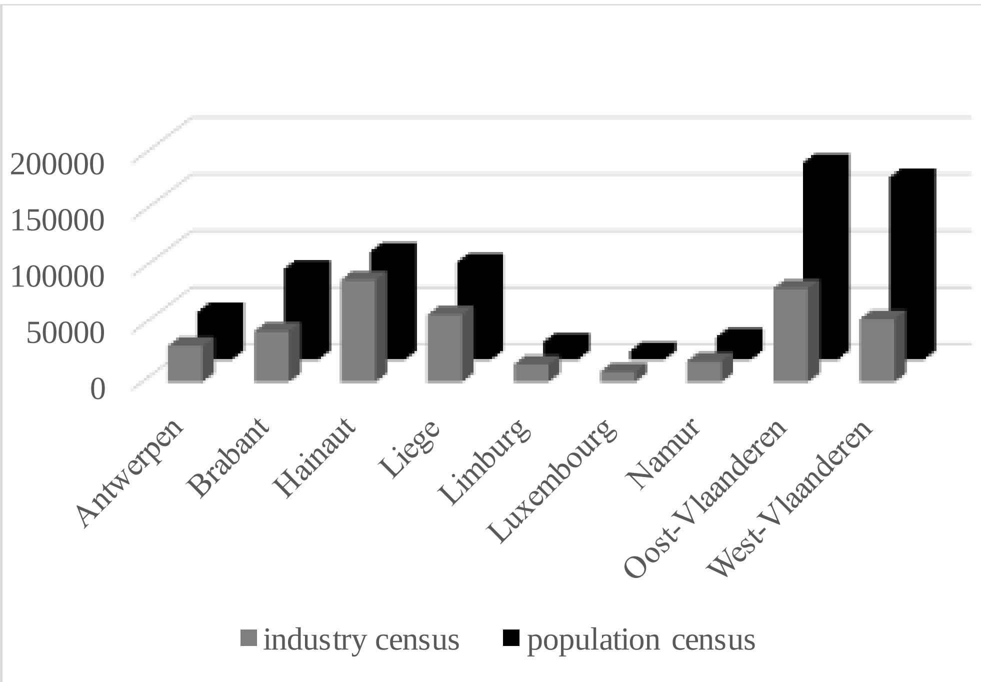
Furthermore, as the census measured the employment on a single day, many seasonal-dependent industry sectors are argued to have been measured unrepresentatively. Of this issue, even the census takers were aware of: “the census is conducted at the beginning of the winter season, at a time in which some professions (amongst other professions, most notably the professions in construction) did not labour for an entire working day” (Census 1846: XIX).[85] Third, employment in public institutes was included in the employment numbers, whereas they have not been excluded in later industry censuses. So, did the industry census of 1846 capture the employment in “military bakeries and poorhouses, prisons and beggar’s houses, schools of lacemaking, charitable housing, or overall all establishments in which products were manufactured with the intention for trade or consumption” (De Brabander 1984: 42).[86] So did De Brabander (1984: 99) estimate that the production in prisons accounted for 4,605 employees, of which most were active in textiles production.

As stressed before, to account for these issues and transform the industry census into a representative number of employees and establishments, we cross-check the employment numbers per industry sector in the industry census with the values of the occupational records of the Belgian population census of 1849. As the population census surveyed the entire

[85] Original citation in French: “le recensement a été fait à l'entrée de l'hiver, à l'époque où certains métiers (entre autres ceux qui tiennent à la construction) ne travaillent pas une journée pleine” (Census 1846: XIX).
[86] Original citation in French: “Des Bulletins seront également remis aux boulangeries militaires et aux manutentions de vivres, aux prisons centrales et aux dépots de mendicité, aux écoles dentellières, aux ateliers de charité, et généralement dans tous les établissement où l’on fabrique des objects qui sont livrés au commerce ou à la consommation.” (De Brabander 1984: 42).

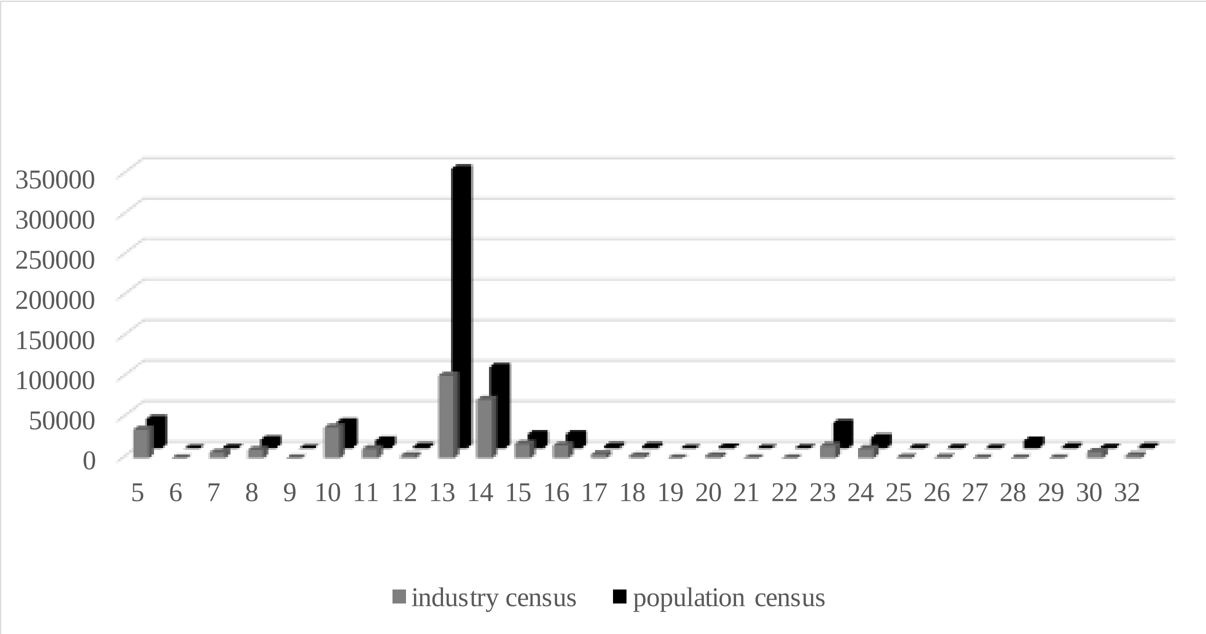
population, the number of employees in the population census accounted for seasonal-dependent employment (as employees stated their predominant occupation in the population census), domestic producers (as these were included in the population census), and the population census did distinguish between people working in public institutions. The population census categorized between seven sectors of industry: foodstuffs (or *nourriture de l'homme*), clothing (or *vétément*), construction (or *batiment*), furniture and wood products (or *ameublement*), textiles (or *industrie manufactures*), metal products (or *industrie metallurgique*), and other industry sectors (or *autres professions*). Although the population census listed the 182 subsectors which were included in these 7 sectors, employment numbers were only provided for these seven sectors of industry. Therefore, we used a twofold approach. We first attributed the employment numbers of the industry census sectors to one of the 7 sectors of the population census. Second, we calculated the employment numbers of the population census across the ISIC divisions, according to the industry census sectoral division.

Figure 2. Discrepancy in provincial numbers between the Belgian industry and population census of 1850



In Figure 2, we plot the differences between the employment total of the industry census and population census over the Belgian provinces. Here, it appears that the industry census was able to paint a more representative image for some regions compared to others. Most notably for the provinces of East and West Flanders, the industry census seems to have undervalued employment gravely, which can be credited to the failed incorporation of the domestic manufacturing in the industry census of 1846, as domestic manufacturing of textiles and apparel was widespread in both provinces. The smaller deviations in Brabant and Liège could as well be explained by the exclusion of domestic manufacturing. So, did the Belgian industry census of 1896 report a large activity of domestic cotton, linen, and woollen textiles and apparel production in Brabant and domestic production of nails, bolts, weapons and knives in Liège.

Figure 3. Discrepancy in sectoral numbers between the Belgian industry and population census of 1850



When taking a look at the discrepancy over sectors in Figure 3, our earlier hypothesis that the exclusion of the domestic-based manufacturing was responsible for the largest deviations between the Belgian population census and industry census seems to be confirmed. The largest discrepancies existed in the manufacturing of textiles (division 13) and apparel (division 14), as both sectors are widely regarded as the sectors in which domestic-based manufacturing was common. Additionally, ISIC division 23 (manufacturing of other non-metallic mineral products) seems to be underestimated as well. Here, we affirm the views of De Brabander (1984: 48) who stressed that employment in this sector was low at the moment of measurement – autumn season – and seasonal labour was widespread in this sector. Therefore, to elevate the number of employees and establishments in the industry census to a representative number, we correct in our database for the undervaluation of these provinces and sectors with the values of the population census.

A.3. Dutch industry census of 1857

Two sources estimate the number of establishments and employees in the industry sector in the Netherlands at a spatial-disaggregated level around 1850. First, we have the statistical series of Brugmans (1956) supplemented by Dansma, De Meere and Noordegraaf (1979), of which both collected data based on a collection of municipal reports during 1843 – 1848. Both sources suffered from two important limitations. On the one hand, these reports often did not measure all employment in industry in a given municipality. Since the municipalities were reluctant to provide this information to the provincial government, the municipal reports before the 1870s often did not contain a lot of information. On the other hand, the collected municipal reports only covered a small percentage of the municipalities in the Netherlands: of the 1209 municipalities existent in 1850, both publications combined present us with data on 75 municipalities.

Second, we have the Condition of the Dutch factories (or *Staat van de Nederlandsche fabrieken*), published in 1859 by the Dutch Society for the promotion of industry (or *Nederlandse Maatschappij ter Bevordering van Nijverheid*). This private organization compiled this comprehensive report by combining a larger collection of municipal reports and a collection of local and provincial reports of the local Chambers of Commerce and Factories in 1850 (Nederlandse Maatschappij 1859: 3). This source provides the number of establishments (and sporadically, even the name of the owner of the factory), the name of the sector, the number of employees, the amount of induced horse power. As Van Gerwen (2008: 340) noted, this report was “not comprehensive”. Indeed, the Condition reported mostly information about the large factories and only contained information for 655 of the 1209 municipalities. In addition, often, the number of employees or the number of establishments were provided, but only rarely both were reported.

Notwithstanding these shortcomings, we chose to use the Condition of the Dutch Factories, as this source covered more municipalities than the combined number of municipalities covered by Brugmans (1956) and Dansma, De Meere and Noordegraaf (1979). Yet, alterations had to be made to convert this source to a representative dataset. First, for the values in which the number of employees or the number of establishments were provided but not both, we used the national average number of employees per establishment or the national average number of establishments per employee per industry branch, to fill in the missing observations. In the cases in which neither the number of employees or the number of establishments were provided, we used the average per capita number of employees and average per capita number of establishments in the neighbouring municipalities to calculate together with the population total of the municipality the number of establishments and employees. To account for the issue of the unreported municipalities, we returned to the aforementioned method of comparing and correcting the number of employees of the industry census with the population census, in particular the occupation records of the Dutch population census of 1849. The Dutch population census of 1849 distinguished between 399 different groups of occupations, of which 139 groups fitted the definition of industry of the ISIC classification.

Figure 4. Discrepancy in provincial numbers between the Dutch industry and population census of 1850

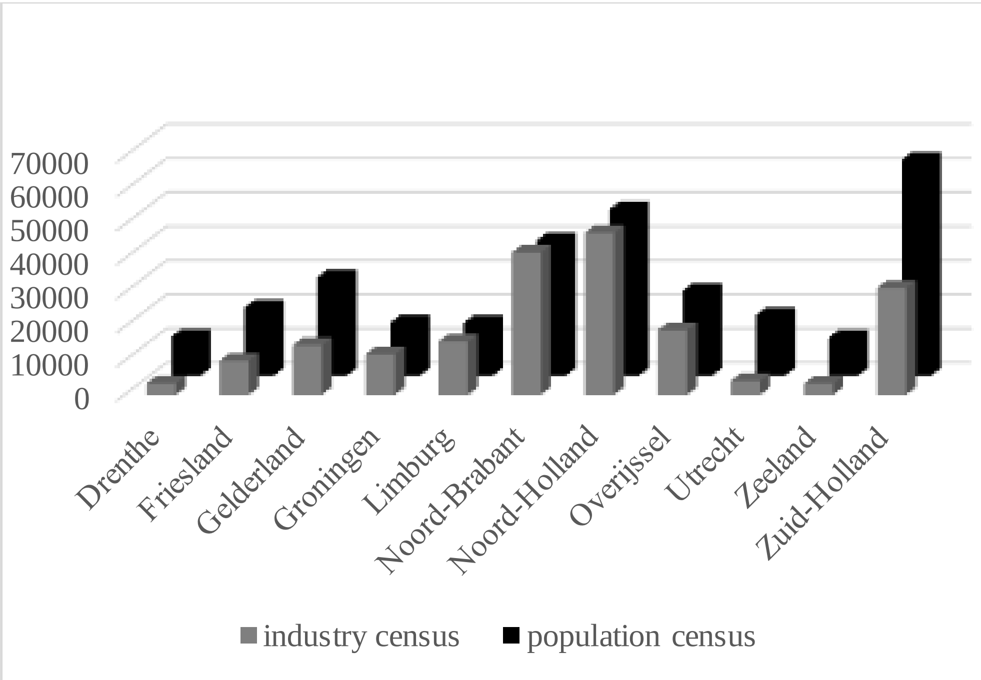
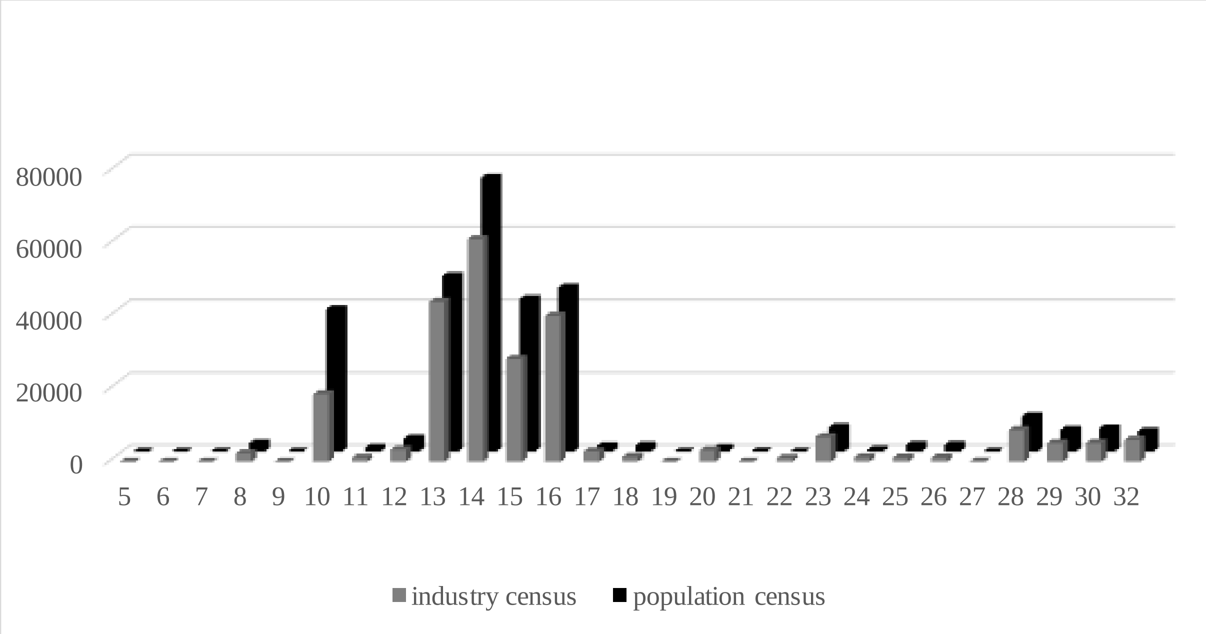


Figure 4 plots the discrepancy in the employment total between the industry census and the occupational records of the population census across provinces. The deviations seem largest for the province of South Holland, and to a lesser degree Gelderland and Friesland. Here, it is worth mentioning that the undervaluation of the employment in industry for the South Holland province could not be credited to a low number of reported municipalities: the Condition (Nederlandse Maatschappij 1859) reported employment for 119 municipalities out of the 143 municipalities in South Holland in 1850, whereas the Condition (Nederlandse Maatschappij

1859) covered only 655 of the 1209 municipalities in the Netherlands in total. Therefore, a more structural problem seems to lie at the basis of this undervaluation.

Figure 5. Discrepancy in sectoral numbers between the Dutch industry and population census of 1850

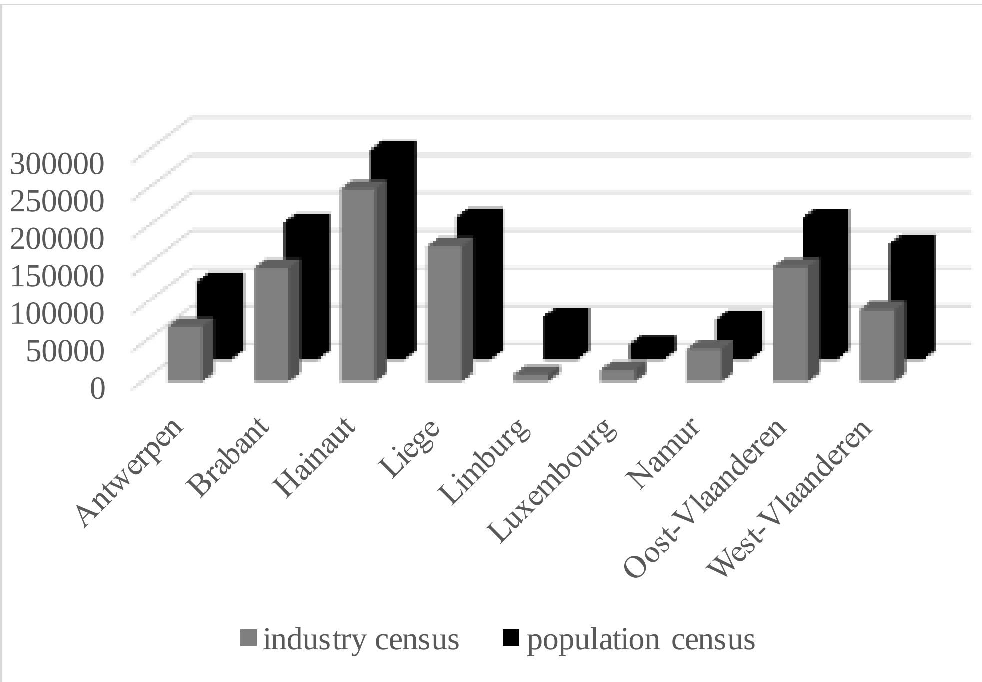


In Figure 5, where we report the discrepancy between the industry census and population census across industry sectors, the population census and the industry census appear to deviate the most for three industry sectors: food products (ISIC division 10), apparel (ISIC division 14), and leather products (ISIC division 15). As these sectors were predominantly active in the South Holland, Gelderland, and Friesland provinces, we can credit the undervaluation of these provinces largely to a systematic undervaluation of these sectors. Since these ISIC divisions were predominantly performed by subsistence farmers as by-employment, we can assume that the Condition (Nederlandse Maatschappij 1859) underreported the by-employment in these sectors in these provinces. As such, by alleviating the number of establishments and employees from the industry census to the population census, similar to as we have done for the Belgian industry census, we create a representative count of the number of employees and establishments in the Netherlands in 1850 on a spatial-disaggregated scale.

A.4. Belgian industry census of 1896

To measure the industry sector in Belgium at the turn of the twentieth century, we made use of the industry census conducted on 31 October 1896, which was digitized in the LOKSTAT project. In part thanks to the intensive preparation of instructions for the census, this census is commonly considered to construct a representative estimation of the industry sector (De Brabander 1984: 58; Bracke 2000: 190). In contrast to the industry census of 1846, this census did include the domestic manufacturing sector. The only significant point of criticism went to the timing of the census. In contrast with the industry census of 1846, which intended to estimate a representative number of the average employment throughout the year, the industry census of 1896 aimed to make a snapshot of the situation on 31 October (Census 1896: 227). Consequentially, seasonal-dependent industries are argued to have been measured poorly in this census (Buyst 2007). Therefore, similar to the Belgian industry census of 1846, we compare the employment numbers of the industry census with the population census conducted on 31 December 1900, under the assumption that the population census was able to measure seasonal employment adequately (Buyst 2007). The population census of 1900 categorized the occupations over 151 sectors, of which 138 sectors fitted the ISIC definition of industry.

Figure 6. Discrepancy in provincial numbers between the Belgian industry and population census of 1850



In Figure 6, we measure the deviations between both sources in employment numbers on the provincial level. Here, it seems that the provinces of West-Flanders, East-Flanders and

Brabant present the largest deviations, which encapsulated the same provinces that were predominantly undervalued in the industry census of 1846. In the industry census of 1846, this could largely be credited to the exclusion of the domestic-based producing activities, but given these findings it appears at first sight that the industry census of 1896 did not adequately measure the domestic-based manufacturing either. In this perspective, the discrepancy in timing between the industry census (held at 31 October 1896) and the population census (held at 31 December 1900) might have played an additional role, as domestic spinning and weaving is considered to have been highly seasonal dependent (e.g. Humphries 2011).

Figure 7. Discrepancy in sectoral numbers between the Belgian industry and population census of 1890

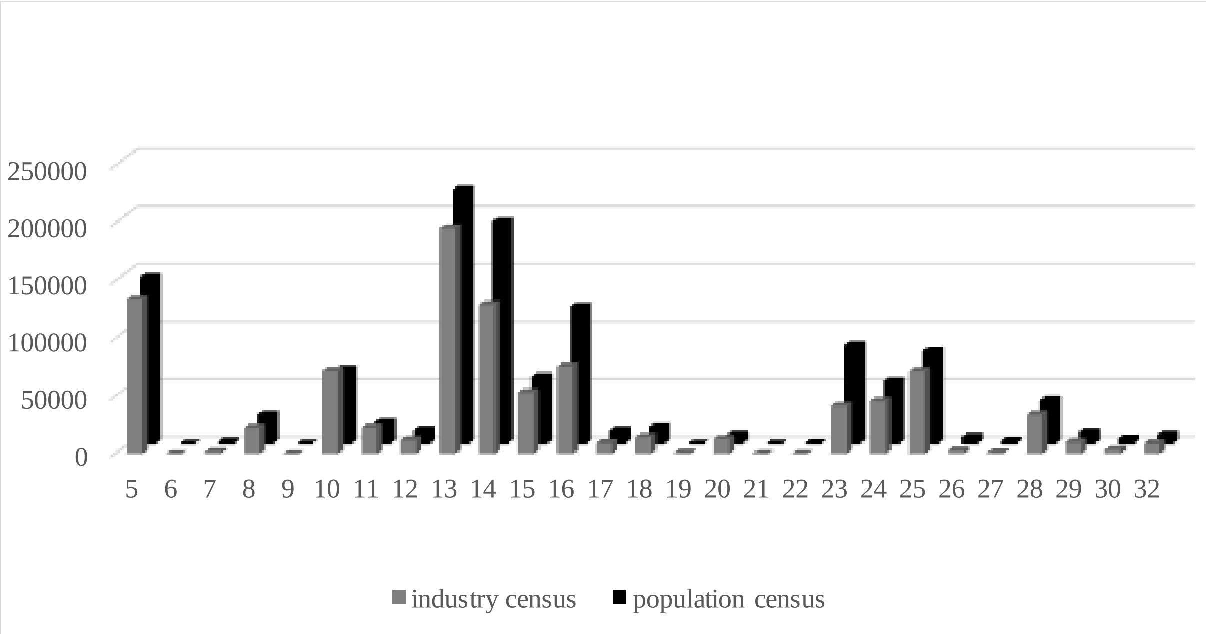


Figure 7 seems to confirm this hypothesis, since the largest deviations between the industry census and population census are found in ISIC division 13 (manufacturing of textiles) and ISIC division 14 (manufacturing of apparel), two sectors which featured notable domestic production. In addition, ISIC division 16 (wood and of products of wood and cork) and ISIC division 23 (other non-metallic mineral products) show large discrepancies. Similarly, both sectors are considered to have been active on a sporadically basis during the period of measurement of the population and industry census. For instance, De Brabander (1984: 48) stressed that the ceramic manufacturing sector was traditionally hardly active in winter season. As such, it appears that the existing discrepancies between both sources could be credited to the large number of casual workers in domestic-based and seasonal-dependent sectors.

Following our method of the industry census of 1846, we therefore multiply the establishment and employment numbers of the industry census with their corresponding values per industry branch of the population census.

A.5. Dutch industry census of 1896[87]

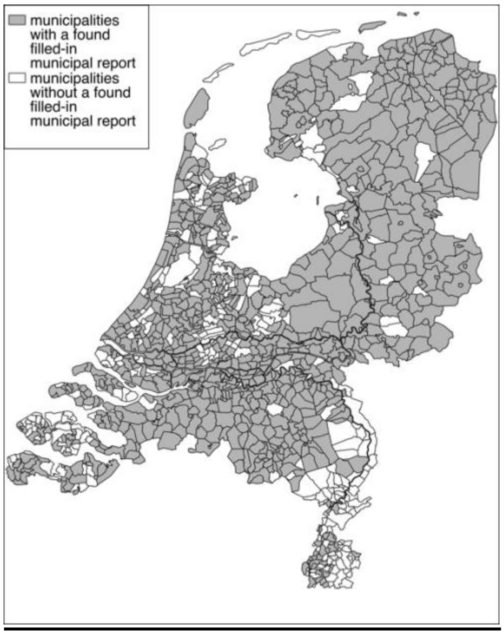
Between the industry census of 1857 (and an update of this census in 1871) and 1930, the year when the first industry census was conducted in the Netherlands, two published data publications inform us about employment in the Dutch industry sector on a spatial-disaggregated level. First, we have the inquiry of H. W. E. Struve and A. A. Bekaar, which intended to report all large manufacturing enterprises in the Netherlands in 1888 - 1891. As such, the inquiry reported 464 firms, in which it is argued to have captured all enterprises in the Netherlands that employed more than 10 people, or made use of a steam engine (Van Gerwen 2008: 343). Second, we have the Description of the Commerce and Industry in the Netherlands (or *Aperçu du Commerce et de l'Industrie des Pays-Bas*) compiled by J.C.A. Everwijn in 1910. Yet, Everwijn (1910) confined his survey to a limited number of – predominantly steam-driven – manufacturing sectors (Everwijn 1910: 14; Van Gerwen 2008: 339 - 340).

Consequently, both sources failed to capture the Dutch manufacturing sector in a complete geographical and sectoral coverage. We filled this gap in the literature by collecting a large collection of Dutch municipal reports, which were composed by the municipal government, to be sent to the Provincial States General of the Netherlands (or *Provinciale Staten-Generaal*). Since the Belgian industry census reported employment numbers for the year 1896, we chose to collect and assemble the large collection of these municipal reports for this year. For most provinces in the Netherlands, these reports were available at their respective provincial government archive. Yet, as the provincial archives of Limburg, Zeeland, North Holland, and South Holland did not preserve these reports, we turned to the local municipal archives in these provinces. For the complete list of municipal archives, we refer to Philips (2019). In addition, as for some municipalities a filled-in municipal report was lacking, we could not obtain a complete geographical coverage. In total, we found for 852 filled-in municipal reports, out of the 1.121 municipalities in the Netherlands (see Figure 8), with the

[87] A more detailed description of this dataset has been described in the article entitled "Construction of a census of companies for the Netherlands in 1896", published in the *Low Countries Journal of Social and Economic History*, 2019, 16 (1), pp. 87-108.

largest number of missing municipalities for the provinces for which we had to turn to the municipal archive. As such, the collection of municipal reports far outpaces the studies of Struve and Bekaar (1891) and Everwijn (1910) in coverage.

Figure 8. Map with the municipalities covered by the sample of the census of companies in 1896



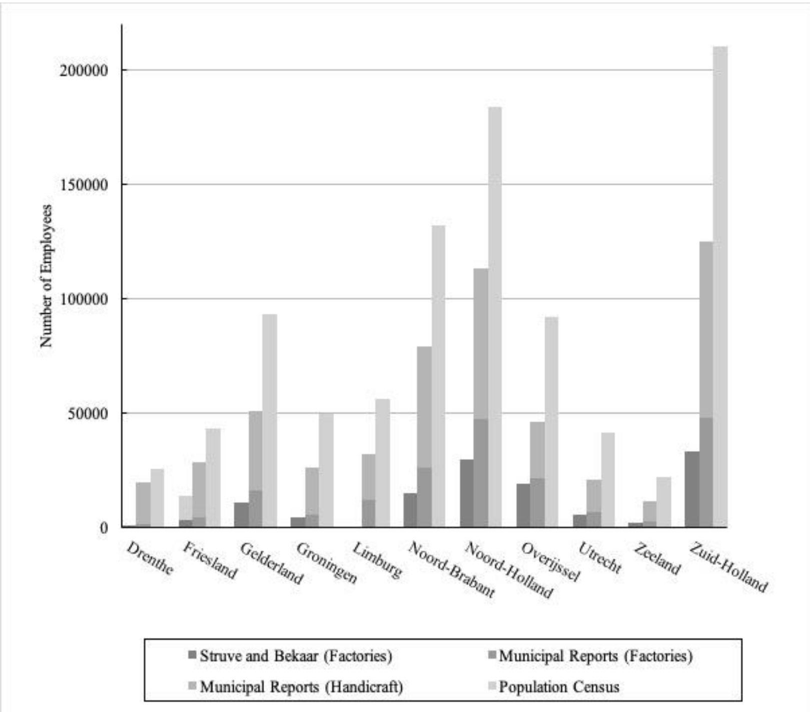
Each municipal report reported the number of employees, the number of establishments, and the number of steam engines and steam boilers within its municipality. Furthermore, each industry establishment was subdivided between factories (or *fabrieken*) if the establishment employed more than 20 people employed and/or if a steam engine was present and handicraft establishments (or *ambachten*) for the other establishments. Yet, three modifications had to be made to arrive to a representative number of establishments and employees.

A first group of corrections had to be made with regards to the non-covered or less-documented municipalities. As Figure 8 shows, we were not able to retrieve statistics for each municipality. A multitude of reasons could have been responsible for holes in our coverage: some municipal governments destroyed these reports, some reports were lost during the merge of municipal archives, for some municipal archives it proved unable to find the reports for the correct benchmark years, and some municipal reports were not filled in. We applied a two-step method to provide employment numbers for each municipality. First, we used the data of Struve and Bekaar (1891) to fill in the employment in the larger factories, as this census is considered to have been able to measure most large factories in the Netherlands (Van Gerwen 2008: 343).

Second, for the municipalities for which we lacked data about the handicraft or domestic industry, we used the average employment per capita in the province for all manufacturing sectors and multiplied them with the total population of the municipality.

A second group of corrections was made in the case that reports were filled in but did not contain all the necessary information. Some reports reported exclusively the number of handicraft establishments, other reports reported exclusively the factory establishments. In that case, we performed a part of our earlier mentioned two-step approach. Some reports listed the number of establishments, but not the number of employees. For those cases, we multiplied the number of establishments with the average number of employees per establishment in that particular branch of industry. In the other case, if we did have numbers of employees but not on the number of establishments, we used the average number of employees in that particular industry branch to estimate the number of establishments.

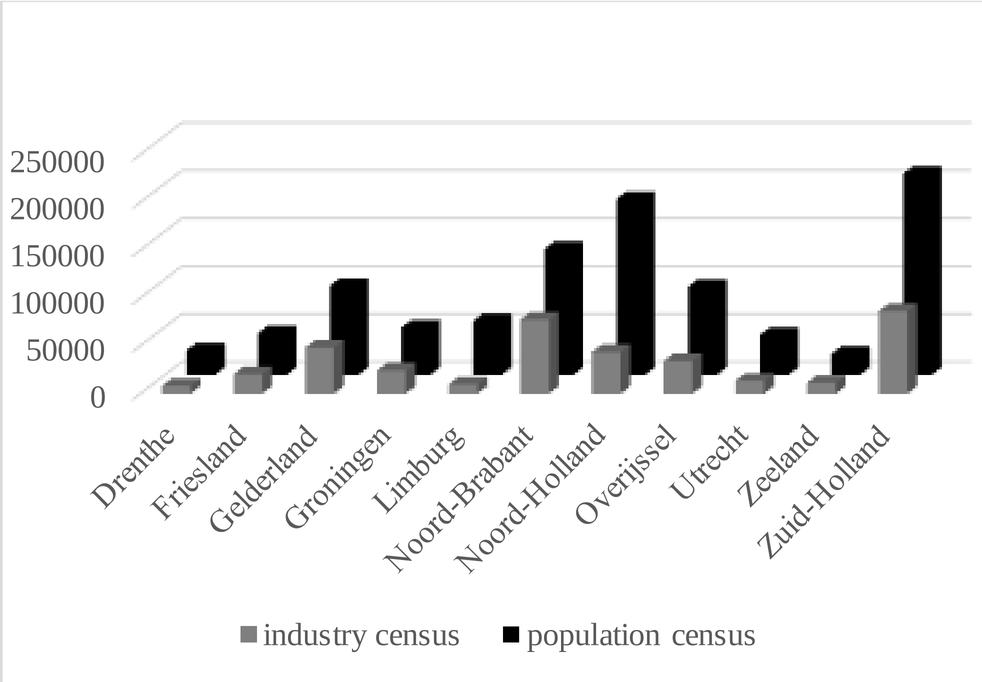
Figure 9. Discrepancy in provincial total between the Dutch industry census, Struve and Bekaar (1891) and population census of 1890



As a third and last step, we compare the employment number of the industry census after both aforementioned sets of corrections with the employment number of the population census of the Netherlands of 1899. For this, we first compare the number of employees across provinces in Figure 9. In addition, as it remained unknown to what degree the inquiry of Struve and Bekaar (1891) was able to measure all large manufacturing factories in the Netherlands at the turn of the twentieth century (Van Gerwen 2008: 343), we also distinguish between factories and handicraft in the employment total of the municipal reports. Based on Figure 9, it seems that the representativeness of the municipal reports differed considerably over provinces. Here, the provinces of Noord-Brabant and Gelderland seem to be measured fairly adequately, capturing approximately half of the employment numbers reported in the population census of 1899. Nonetheless, this was less true for the provinces of North Holland, South Holland, and Overijssel. At the same time, we notice that, compared to Struve and Bekaar (1891), the municipal reports were able to capture the large factories in the Netherlands.

Additionally, in Figure 10, we plot the deviations across sectors between the population census and the industry census. The largest deviations seem to be situated in ISIC division 10 (manufacturing of foodstuffs), ISIC division 13 (manufacturing of textiles), ISIC division 14 (manufacturing of apparel), and ISIC division 15 (manufacturing of leather products). Therefore, we can again notice that the undervalued sectors are mainly the result of a failure to represent the handicraft establishments and domestic production: domestic and small-scale production was predominant in the food, textiles, apparel producing sectors, often even performed as by-employment by subsistence farmers. Therefore, as done for the aforementioned industry censuses, we elevate the numbers of establishments and employees as reported in the municipal reports with the number of establishments and employees per industry branch and province as reported in the population census to create a representative dataset.

Figure 10. Discrepancy in sectoral total between the Dutch and population census of 1890



Appendix B. Correspondence tables for industry sectors

When studying the manufacturing sector over time, naturally, the question arises: which sectors are considered to be part of the manufacturing sector? This becomes even more problematic when turning to historical census data, as we are confronted with continuously changing definitions and classifications in the industry censuses. To standardize the industry sectors over time, we attribute all industrial census sectors of the industrial censuses individually to the most-fitting sector in the fourth revision of the ISIC classification system. As the ISIC classification is a well-defined classification which leaves relatively little room for misinterpretations, it presents an ideal framework for classifying the industrial activities in the original industry censuses. In particular, we link each industry census sector with the most fitting 4-digit level of the ISIC Revision 4 classification. Consequentially, we aggregate the 4-digit level of the ISIC classification to the ISIC 2-digit level, providing us of a database on twenty-one sectors of manufacturing and five sectors of mining and quarrying. The list of the industry census sectors with their ISIC counterpart are provided in Appendix B. Yet, we first briefly discuss the classification systems in the used industry censuses, as these imposed limitations on our linking operation.

In order to compare employment across industry sectors over time, previous studies on industrialization in the Low Countries predominantly followed two strategies. On the one hand, studies often aggregated the industry census sectors in a limited number of broad categories. On the other hand, studies often used or constructed correspondence tables between the industry census classifications. Yet, even such an operation turns complex if you are studying industrial activities on the long-run, as systematically distributing different original census sectors in different sector groups over time often leads to attribution problems. For instance: factories that manufactured ice - as a cooling system - were classified in the Belgian industry census of 1846 as part of the industry sector group of food products, but were classified in the Belgian industry census of 1896 as part of the sector of production of beverages. Consequentially, in the Belgian industry census of 1937, the sector was defined again as a sub-sector in the manufacture of food products, whereas it was considered as a service sector in the Belgian industry census of 1970. Therefore, attributing sectors in a standard classification – with the construction of a link between each industry census sector individually to the ISIC sector counterpart, as we have done – removes these problems of attribution.

Table 1. Classification systems of the statistics documenting the manufacturing sector in the Netherlands and Belgium

	the Netherlands	**Belgium**
1820	census-specific classification system	
1850	census-specific classification system	Nationale Industrie Statistieken (NIS), first version
1890	census-specific classification system	Nationale Industrie Statistieken (NIS), second version
1930	Beroepen Classicatie (BC), first version	Nationale Industrie Statistieken (NIS), fourth version
1970	Beroepen Classicatie (BC), version 1963	International Standard of Industry Classification (ISIC), first version
2010	Standaard Bedrijfsindeling (SBI), version 2008	Statistical Classification of Economic Activities in the European Community (NACE-BE), version 2008

In addition, the linkage of classification systems is highly problematic, given the multitude of changes in these classification systems over time. Linking the classification systems one-on-one would therefore result in a complex set of relations between the classified industry sectors, in which in particular the industry sectors of the oldest industry sectors would be heavily distorted. As Table 1 shows, changes in the classification systems over time were plentiful in both the Netherlands and Belgium. In the Netherlands, the *Beroepen Classificatie* (BC) used in the industry census of 1930 was the first systematic classification system, as the previous industry censuses listed a number of industry sectors unsystematically. In the Dutch industry census of 1978, an altered version of the BC was used, which would form the basis for the later *Standaard Bedrijfsindeling* (SBI). This SBI was constructed in 1974 and featured two major updates, in 1993 and 2008, for which the most recent version has a direct conversion table to the ISIC and NACE classification systems. The SBI 2008 was used for the Dutch industry census of 2010. The Belgian industry censuses before 1945 followed a standard classification system, commonly referred to as the *Nationale Industrie Statistieken* (NIS). Yet, this classification underwent several changes over time: for almost every Belgian industry census, significant alternations were made, formulating new sub-sectoral categories or listing new industry sectors. After the Belgian industry census of 1947, a classification system comparable with the ISIC 1948 edition was developed. Therefore, the Belgian industry censuses of 1970 and 2010 followed a classification system largely in line with the ISIC classification.

Table 2. Number of manufacturing and mining/quarrying sectors in the classification systems of the used sources

	the Netherlands	**Belgium**
1820	527 unique, not-broken down manufacturing sectors	
1850	196 unique, not-broken down manufacturing sectors	278 unique, not-broken down manufacturing sectors
1890	2,982 unique, not-broken down manufacturing sectors	17 first-level, 59 second-level, 856 third-level sectors
1930	15 first-level, 310 second-level sectors	16 first-level, 69 second-level, 1149 three-level sectors
1970	152 unique, not-broken down manufacturing sectors	6 first-level, 25 second-level, 134 third-level sectors
2010	2 first-level, 27 second-level, 101 third-level, 264 fourth-level sectors (SBI 2008)	2 first-level, 29 second-level, 105 third-level, 245 third-level, 275 fourth-level sectors (NACE BEL 08)

Therefore, as aforementioned, we constructed a correspondence table between each industry census sectors and their respective ISIC revision 4 sector counterparts on the four-digit level. For the manufacturing sector, the ISIC classification identifies 23 two-digit level sectors, 68 three-digit level sectors, and 137 four-digit level sectors. Including the mining and quarrying sectors, this adds another 5 two-digit level sectors, 10 three-digit level sectors, and 14 four-digit level sectors. As Table 2 shows, the number of industry census sectors differed considerably across the industry censuses. At first sight, it seems that the industry censuses during 1820-1930 were more detailed than the industry censuses during 1970-2010. Yet, considering that the industry census classifications after 1950 followed to a large extent international conventions in classifying industry sectors, this could be assumed not to have distorted the linkage gravely.

Yet, we deviated in two respects from linking the industry census sectors with the latest revision of ISIC classification, related to two two-digit sectors: ISIC division 31 (*Manufacture of furniture*) and ISIC division 33 (*Repair and installation of machinery and equipment*), due to the limitations the industry censuses imposed.

First, ISIC division 31 (*Manufacture of furniture*) was a creation of the third revision of the ISIC classification. In the original and first two revisions of the ISIC classification, furniture manufacturing was categorized as a sub-sector of the manufacturing of wooden products. Similarly, in many of our used industry censuses, it was impossible to distinguish between wooden products and furniture. Therefore, we chose to classify all furniture manufacturing - which would be categorized in the ISIC division 31 (*Manufacture of furniture*) in the fourth revision of the ISIC classification - rather under ISIC class 1629 (*Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials*), following the categorization of the first three versions of the ISIC classification system. Since nearly all furniture during the nineteenth century was made out of wood, this would not impose a large implication for the results. For the industry censuses of 1970 and 2010, this could lead to slight distortions, although the majority of the furniture manufacturing in the Low Countries at present still derives from inputs of wood.

Second, deviation relates to the ISIC division 33 (*Repair and installation of machinery and equipment*). Similar to the manufacturing of furniture, many of the older industry censuses did not always distinguish neatly between the manufacturing of machinery and equipment and the repair of machinery and equipment. Following the laws of the division of labour, most of the repair and installation processes took place within the company itself during the nineteenth century, while this became a specific activity for certain companies during the twentieth century. Therefore, we chose to attribute each ISIC four-digit sector in the 33 subdivision to the sector in which the manufacturing of this product took place, as presented in Table 4. Therefore, all in all, ISIC division 31 (*Manufacture of furniture*) and ISIC division 33 (*Repair and installation of machinery and equipment*) were removed from our dataset and rather aggregated in other ISIC divisions.

Table 3. Transformation of the ISIC division 33 to other ISIC classes

Original ISIC class number	Original ISIC class name	Transforma-tion to ISIC class number	Transformation to ISIC class name
3311	Repair of fabricated metal products	2599	Manufacture of other fabricated metal products n.e.c.
3312	Repair of machinery	2819	Manufacture of other general-purpose machinery
3313	Repair of electronic and optical equipment	2680	Manufacture of magnetic and optical media
3314	Repair of electrical equipment	2790	Manufacture of other electrical equipment
3315	Repair of transport equipment, except motor vehicles	3099	Manufacture of other transport equipment n.e.c.
3319	Repair of other equipment	3290	Other manufacturing n.e.c.
3320	Installation of industrial machinery and equipment	2819	Manufacture of other general-purpose machinery

Appendix B.1. Correspondence tables between industry censuses and ISIC

See online appendix B.1.

Appendix C. Number of employees in industry

Based on the industry censuses, as mentioned in section 1.4., we define in our dataset an employee as "the yearly average full time equivalent of people employed in the manufacturing sector, regardless of age or their function in the production process".

First, we turn to the "yearly average full time equivalent". The Belgian and Dutch industry censuses of 1820 - 1890 - with the exception of the Belgian industry census of 1846 -

report the number of employees working at the date in which the industry census was registered. The Belgian industry census of 1846 on the other hand intended to measure the 'average' number of employees (IC 1846: LX), which was problematic as it remains until present unclear what this 'average' actually measured. Subsequently, De Brabander (1984: 43) expressed doubts whether the census actually succeeded in providing a yearly average number of employees. Moreover, for all industry censuses, it remains unclear to what degree was accounted for temporary lay-offs, seasonal-dependent employment or occasional industrial activities. As presented in Appendix A, we accounted for these seasonal dependent and time-varying activities in the industry censuses of 1820-1890, by controlling for the under –and overvaluations with the values in the population censuses, which we argue present a number of employees that measures the yearly average full time equivalent. The industry censuses of 1930-2010 controlled for seasonal dependent activities, by using different dates of measurement. For instance, in the Dutch industry census of 1930, most of the sectors were measured on 1 December, but seasonal dependent sectors were visited on other, more representative dates: posting offices were visited in November, peat-digging sites in June, beet sugar factories in November and tube manufacturing companies in July. Similarly, the Belgian industry census of 1937 measured most sectors on 27 February, but also gather information on six additional reference dates.

Not only did the dataset aim to construct a representative average of employment in a single year, also we present a full time equivalent of the number of employees. In the case of the industry censuses of 1820, 1850, 1890 and 1930, the average number of full-time employees was recorded. The Belgian industry census of 1970 excluded employees which worked less than 15 hours a week (Census 1970: 18). As the Dutch industry census of 1978 distinguished in its employment numbers between employees working less and more than 15 hours, we excluded the employees working less than 15 hours to make the results comparable to the Belgian industry census of 1970. Similarly, the Belgian industry census of 2010 only recorded employees who were full-time employed. As the Dutch industry census of 2010 recorded separately part-time workers and full-time workers, for which 12 hours a week was the threshold between both, we again removed all people working less than 12 hours per week in order to make a fitting comparison with the Belgian industry census.

Second, we turn to the "regardless of age". The 1819 industry census, published by Brugmans (1956), listed next to the number of adult employees in industry, also the number of children employed in the manufacturing sector. Since it remains unclear what age groups the industry census included within the category of child employees, we included both adult and child employees in our number of employees of the industry census of 1820. The later censuses similarly made a division over age, although this subdivision changed over census to census, for which the distinguished age groups demarcated increasingly among older age groups. For instance, whereas the Belgian industry census of 1846 subdivided between employees younger than 9 years old, 9 – 12 years old, 12 – 16 years old and adults (+ 16 years old), the industry census of 1896 subdivided between employees younger than 12 years old, 12 – 14 years old, 14 – 16 years old, 16 – 21 years old and adult (+ 21 years old) employees and the Belgian industry census of 1937 subdivided between employees between 14 – 16 years old, 16 – 18 years old, 18 – 21 years old and adult (+ 21 years old) employees. A similar evolution seems to have occurred for the Dutch industry censuses. As we were unable to make a consistent division over age groups in our dataset, we aggregated child and adult employees, regardless of age, in the number of employees.

Third, we turn to the "regardless of their function in the production process". Similarly, it proved impossible to differentiate among groups of employees over time. So, did the Belgian industry censuses of 1937, 1970, 2010 and the Dutch industry census of 1978 differentiate between white and blue collars workers, whereas the other industry censuses did not. Likewise, the Dutch industry censuses of 1896 and 1930 and the Belgian industry censuses of 1846, 1896 and 1937 did report separately managerial staff or entrepreneurs, but the other industry censuses did not. Similarly, only the Belgian industry censuses of 1846 and 1896 differentiate between regular employees and assisting family members, most notably spouses. Therefore, additionally these different types of employees we aggregated altogether in the number of employees.

Appendix C.1. Number of employees on NUTS2 level (1820-1890)

See online appendix C.1.

Appendix C.2. Number of employees on LAU2 level (1890-2010)

See online appendix C.2.

Appendix D. Number of establishments in industry

Based on the industry censuses, as mentioned in section 1.4., we define in our dataset an establishment as "(a part of) a private enterprise where the industrial activity is taking place in which at least a single person is employed".

First, we turn to the "(a part of a) private enterprise where the industrial activity is taking place". As the location of manufacturing is the main study object of this manuscript, issues regarding obtaining information about the location of industrial activity evidently arise soon. In general, industry censuses have measured the location of industry in two different approaches: the location of the main holding of the company or the location of the establishment. Especially towards the more recent period, as large firms with multiple establishments across different cities arise, the differences between both definitions become large. Our interest goes out to the actual location where the industrial activity takes place, thanks to which our preference goes towards the second definition. Therefore, we follow the definition of an establishment, rather than the definition of a company or business.

The industry censuses before 2010 followed this definition of an establishment. So, did the Belgian-Dutch industry census of 1819 measure the location of "each establishment, which on its own makes a contribution [of production] (…) as soon as the establishment can be recognized as an establishment on its own" (Dansma, De Meere, and Noordegraaf 1979: 472-474).[88] Likewise, the Belgian industry censuses of 1846 and 1896 are argued to have measured the location of industry according to the location where the actual labour took place (De Brabander 1984: 44, 55). The Dutch industry census of 1857 likewise measured the location of industry as the place where the "establishment could be found" (Nederlandse maatschappij 1857: 6),[89] a definition which was stated clearly in the entry forms of the municipal reports, therefore applicable to the Dutch industry censuses of 1857 and 1896. The Dutch industry census of 1930 defined the establishment as "a separate factory, workshop, shop, office, or elsewise" (Census 1930: XXIII),[90] a definition which remained largely the same for the industry census of 1978 (Census 1978: 17). This definition of the individual establishment was similarly

[88] Original citation in Dutch: "In deze wordt elke inrigting, welke op zich zelve een tak van bestaan uitmaakt, gesteld; al ware het, dat dezelve ook met andere vereenigd ware; zoodra die maar op zich zelve kan worden gerekend, komt zij als inrigting te voorschijn." (Dansma, De Meere, and Noordegraaf 1979: 472-474).
[89] Original citation in Dutch: "zij wenschten niet zoo zeer een opgaaf van de soorten van fabrieken, als wel van de verschillende werkplaatsen, die er gevonden werden, en van de ondernemers, die ze bestuurden". (Nederlandse maatschappij 1857: 6).
[90] Original citation in Dutch: "Onder vestiging is verstaan elke afzonderlijk gelegen fabriek, werkplaats, winkel, kantoor (...)" (Census 1930: XXIII).

followed by the Belgian industry census of 1937 (Census 1937: 18) and 1970 (Census 1970: 19).

However, the most notable databases in the Low Countries that estimated the labour force in 2010 - the Chambers of Commerce in the Netherlands and the Office of Statistics in Belgium - offer aggregated data at the level of the main company holding, not the establishment. To solve this issue, we rather opted for the data of the Dutch LISA register and the database of the Belgian office of social security in 2010, which did report the data on the establishment level. The LISA dataset measure the location of industry at the establishment level, or as the location of "each factory, work station, office, shop, or other business space" (Stichting LISA 2015: 6).[91] Similarly, the Belgian office of statistics define the location of industry at "the place of the establishment" (RSZ 2013: 11).[92]

As we are exclusively interested in the establishments of private enterprises, we therefore excluded all establishments in industry owned by the government. With the Dutch industry census of 1896, given that we were confronted with individual data on the establishment level, this was possible to extract. For instance, we excluded the construction sites of the Dutch marine and the bakeries located in the military barracks. Yet, the public establishments were impossible to exclude in the other industry censuses.

Second, we turn to the "in which at least a single person is employed". The self-employment establishments, hereby referring to establishments where only one employee worked and therefore the employee acted as the manager, were captured in all industry censuses. When we encountered such self-employed companies, they were recorded in our results as one establishment and one employee. In the cases where only employment numbers were provided in the industry censuses – as such was often the case for proto-industrial, domestic textiles production – but the number of establishments not, we used the average number of employees per establishment of that given industry census sector to calculate the number of establishments. Non-active establishments were often recorded in the used statistics.

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[91] Original citation in Dutch: "Locatie van een onderneming, instelling of zelfstandige beroepsbeoefenaar (dat wil zeggen elke fabriek, werkplaats, kantoor, winkel of andere bedrijfsruimte, dan wel elk complex daarvan) waarin of van waaruit een economische activiteit of zelfstandig (vrij) beroep wordt uitgeoefend" (Stichting LISA 2015: 6).

[92] Original citation in Dutch: "De plaats van de vestiging, die de plaats van tewerkstelling van de werknemer bepaalt, is de gemeente (van de vestigingseenheid) waar de werknemer is tewerkgesteld op het einde van het kwartaal." (RSZ 2013: 11).

Since these establishments did not employ at least a single employee, we excluded these establishments.

Appendix D.1. Number of establishments on NUTS2 level (1820-1890)

See online appendix D.1.

Appendix D.2. Number of establishments on LAU2 level (1890-2010)

See online appendix D.2.

Appendix E. Number of steam engines in industry (1820-1930)

For the benchmark years of 1820, 1850, 1890 and 1930, we estimated the number of steam engines, steam boilers, and the omitted steam power in horse power of these machines per ISIC 2-digit sector and per province for 1820-1890 and per municipality for 1890-1930. The number of steam engines and steam boilers were reported in the Belgian industry censuses of 1846, 1896 and 1937, as well as the Dutch industry censuses of 1896 and 1930. Yet, the Belgian-Dutch industry census of 1819 and the Dutch industry census of 1857 did not report these numbers, due to which we turned to alternative sources.

For Belgium in 1820, we turned to Van Neck (1979: 468-477), which listed the steam engines per province. Van Neck differentiated these steam engines in a limited number of industry sectors, based on which we attribute these engines to the most appropriate ISIC 2-digit sector. For the Netherlands in 1820 and 1850, in accordance with Griffiths (1979) and Lintsen (Lintsen and Steenaard 1989, Lintsen 1995), we used two sources to construct the number of all steam engines in the Netherlands. First, we used the inventory of all steam plants in the first half of the nineteenth century as documented by the Ministry of Internal Affairs, collected by Steenaard (1989). As this dataset is argued to only measure approximately half of the total number of steam engines in the Netherlands (Lintsen and Steenaard 1989), we augmented the inventory with the surveys of the steam plants in the Netherlands in 1851. These surveys were requested by the Dutch provincial governors in 1851, at the request of the Dutch ministry of National Manufacturing (or *Ministerie van Nationale Nijverheid*), and preserved in the national archive.[93] Again, we attributed the sectors of industry to the most appropriate ISIC 2-digit sector.

Appendix E.1. Number of steam engines on NUTS2 level (1820-1890)

See online appendix E.1.

Appendix E.2. Number of steam engines on LAU2 level (1890-1930)

See online appendix E.2.

[93] These surveys are held in the archive of the Dutch Ministry of Manufacturing (*ARA Nationale Nijverheid*). The following codes provide the dates when the lists of steam engines were sent by the provincial governments and their inventory number. For Drenthe: *ARA Nationale Nijverheid*, 07/03/1851, number 66. For Friesland: *ARA Nationale Nijverheid*, 24/03/1851, number 122. For Gelderland: *ARA Nationale Nijverheid*, 31/03/1851, number 95. For Groningen: *ARA Nationale Nijverheid*, 24/03/1851, number 123. For Limburg: *ARA Nationale Nijverheid*, 22/08/1851, number 130. For Noord-Brabant: *ARA Nationale Nijverheid*, 15/04/1851, number 67. For Noord-Holland: *ARA Nationale Nijverheid*, 16/04/1851, number 75. For Overijssel: *ARA Nationale Nijverheid*, 05/04/1851, number 103. For Utrecht: *ARA Nationale Nijverheid*, 08/03/1851, number 102. For Zeeland: *ARA Nationale Nijverheid*, 17/04/1851, number 63. For Zuid-Holland: *ARA Nationale Nijverheid*, 25/03/1851, number 60.