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Entrepreneurship, institutions and growth in European regions: a uniform mechanism?

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Abstract

In this paper we present an alternative empirical strategy that sheds light on the importance of institutional quality for regional economic growth. The fundamental problem in this type of research is that institutional quality cannot be measured directly. Existing proxies are typically highly correlated with and endogenous to our dependent variable. We therefore propose a method that is akin to growth accounting, where we refer to the unexplained residual of a production function as total factor productivity. First we run a standard growth regression, including the usual suspects, on 90 European NUTS-2 and 3 regions. The residual variation in regional growth then includes the effect of the fundamentally latent variable that is institutional quality. If this is the case, then variables for which we may assume the effect on growth is strongly moderated through institutional quality, should have a different marginal effect on residual growth at the aggregation levels at which institutions operate. Theory and preliminary empirical evidence suggests that the effect of entrepreneurial activity is strongly moderated by institutional quality. We can thus test the hypothesis that the marginal effect of entrepreneurship on growth differs across regions and countries in our data. We indeed establish that entrepreneurial activity has a positive effect on growth. That is, entrepreneurial activity helps explain the residual variance in our standard growth regressions. However, this effect is not significant when we control for unobserved country differences in a multilevel analysis. We find that most of the cross regional variation is due to between country variation in average entrepreneurial activity, and that there is no longer an effect at the within-country regional level. In a latent class analysis, however, we do not find statistically significant differences in the coefficient across (groups of) regions after controlling for country effects. That is, our data suggests that country level institutional quality is most important for the effect of entrepreneurial activity on growth. After controlling for those differences, regions do not cluster in different classes. This also suggests that the difference between for example rural and urban regions in our sample is not significant, as such regions do not cluster in different groups. Before we draw strong conclusions, however, we note that this may be due to the administrative nature of our regional classification.

Keywords: Institutions, Entrepreneurship, Regional Growth, Multilevel Model, Latent Class Model

JEL classification: E02; L26; R11; O43; O47

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1. Introduction

Economists have been trying to disentangle the causes of economic growth for a long time. The literature has moved from proximate causes of growth, such as factor accumulation (Solow, 1956) technical change (Romer, 1986) and human capital accumulation (Lucas, 1988), to a consensus that there are 'deeper roots' underlying endogenous human capital formation and technical change. Acemoglu et al. (2000) refers to these ultimate causes as "the luck hypothesis", "the geography hypothesis", "the culture hypothesis" and "the institutional hypothesis". Acemoglu (2009) presents a strong empirical and theoretical case for the latter, and a new consensus seems to have emerged (Rodrik, 2004). Voicing the new consensus Rodrik (2004) suggests institutional quality in fact trumps the importance of more traditional development factors such as geography, FDI, trade and resources. As Rodríguez-Pose (2013, p.1036) put it: "It's the Institutions, Stupid!" and argues that institutions differ and matter a lot at the regional and even local level. By taking the institutional context for granted, the above mentioned neoclassical and endogenous growth models typically prescribed a one-size-fit-all policy that yielded only limited success to date (Barca, 2009; Yeung, 2000). As shown in Srholec (2010) innovation at the regional level can vary quite significantly, even within the same country due to "regional framework conditions" and Zeilstra and Elhorst (2012) similarly shows "regional conditions" explain variation in regional unemployment rates. In this paper we will therefore search for the impacts of institutional quality on regional growth.

The effort to uncover these impacts, however, is greatly frustrated by the fact that "institutional quality" is a very fuzzy, elusive and multidimensional concept. We cannot ever hope to measure institutional quality as we might the labor force and capital stock (and even that is far from trivial!). Moreover, the proxies we have are typically collected at the national level. And finally, as (Rodrik, 2004, p.10) states "institutional quality [is] as endogenous to income levels as anything can possibly be". This then holds a fortiori for the currently available proxies for institutional quality used in the literature to date. The problem is that for example indicators based on expert opinion on the strength and security of property rights in a country or region are bound to be heavily influenced by such things as GDP and GDP-growth that appear as our dependent variables. Acemoglu et al. (2000) suggest the use of truly exogenous instruments for institutional quality and show that indeed the effect of property rights protection is positive and significant when using settler mortality rates in the distant past as instruments. But when considering regional growth in Europe, as we do in this paper, good instruments are hard to come by.[1] And variation in a proxy like property rights protection is limited to begin with. In this paper we therefore propose an alternative empirical strategy to get at the impact of institutional quality on growth.

This strategy involves taking institutional quality to be a fundamentally latent variable and building on the assumption that it affects growth by moderating the effect of more visible, proximate causes. In this paper we propose entrepreneurship for this purpose. Entrepreneurship varies quite significantly across European regions (Reynolds et al., 1994; Audretsch and Fritsch, 2002; Sternberg, 2009; Bosma, 2009). [2]

High rates of entrepreneurship are theoretically associated with high levels of economic growth, but in empirical research the evidence is more mixed. We argue that entrepreneurship only contributes to economic growth in the right institutional setting. Here we build on the "Baumol Hypothesis" which states that the supply of entrepreneurial talent is evenly and randomly distributed in the population and across regions, but that the set of norms and rules will dictate the ultimate effect of entrepreneurship on economic growth through the allocation of entrepreneurial resources over types of activity (Baumol, 1990). This hypothesis thus predicts heterogeneous effects of entrepreneurship on GDP growth when comparing regions with different institutional frameworks. [3] Furthermore, the multilevel structure of our data allows us to

[1] A notable example is Fritsch and Wyrwich (2014) who use historic 1925 self employment rates for German regions as an instrument for what they refer to as an entrepreneurial culture. Their focus is on employment growth, however.

[2] In our dataset self-reported innovative entrepreneurship ranges from 0.09 percent in Portugal - Norte to 2.66 percent in Hamburg - Germany. There are also large within-country differences, with the minimum of self-reported entrepreneurs in Germany being 0.44 percent in Sachsen-Anhalt. This shows the regional level is the relevant level to study as we lose a lot of information by aggregating to the national level.

[3] Baumol (1990) also argued that entrepreneurial talent need not allocate into categories that one would necessarily measure as

determine whether the effect of entrepreneurship on growth mainly reveals itself at the regional or at the national level.

Our empirical strategy involves first running a standard, pooled OLS growth regression for 90 EU NUTS-2/3 regions. In extending that regression we find that entrepreneurial activity is positively correlated with growth, also when we control for a range of regional characteristics. If we estimate the same model in a multilevel specification we find that a model with different intercepts (average growth rates) per country fits our data better. That specification is also preferred over a multilevel model with varying slope coefficients across countries. This suggests that the marginal effect of entrepreneurial activity on growth is not statistically different across regions or countries, controlling for country average growth rates. In that model the country level average entrepreneurship rate remains positively significant, whereas the regional entrepreneurship deviations from the national average are not. This suggests institutions affecting the contribution of entrepreneurial activity to growth operate at the national level and intra-national spillovers are important.

To double-check this result, we first generated residual growth from a standard pooled OLS and multilevel model excluding entrepreneurship. We then regressed entrepreneurship on these residuals in an unconditional latent class model. Using the pooled OLS or multilevel residuals we find that the data clusters into a single class. Thus we cannot reject the hypothesis that the marginal contribution of entrepreneurship to growth is the same across regions, especially within the same country. Our results suggest that national level institutions are important and/or there are mechanisms at work that equalise the marginal productivity of entrepreneurial talent within countries and across European regions. Such mechanisms might include mobility of entrepreneurs and the workers and the capital they need to start-up their ventures. Our analysis, however, does not allow us to draw any strong conclusions on that. Instead, our analysis fails to find support for any theories that predict different marginal effects of entrepreneurial activity across (groups of) regions.

The contribution of our paper is twofold. First, we want to see whether a fundamental driver of economic growth - the institutional framework - reveals itself through a more proximate cause - entrepreneurial activity. Second, we investigate whether the impact of institutional quality on entrepreneurship operates mainly at the regional or national level. The paper thus makes a clear contribution to three literatures. In Institutional Economics the link between institutions and growth has been extensively described but researchers struggle to find ways to make this effect empirically visible. Entrepreneurship researchers have been very successful in finding the factors that contribute to (successful) entrepreneurial activity, but to date little research has gone into the importance of regional and national institutional contexts. And finally, by taking a regional perspective, we also contribute to the empirical literature on regional growth and economic geography, introducing entrepreneurship and our latent class methodology in that literature. We research this hypothesis in a cross-sectional framework and not a panel study, as we want to study long-term growth rates and not yearly variations in GDP growth which could be largely due to business cycle fluctuations.

The remainder of this paper is structured as follows. In the next section, we present the background of our paper describing the different literature strands that our paper can be positioned in, and the relevance of combining them. Section 3 presents our empirical strategy and briefly derives the main equations we estimate. Section 4 presents our data and shows the empirical results. Finally, we conclude with a discussion of our results and agenda for further research.

entrepreneurial activity, such as political bureaucracies, crime or other rent seeking activities. We measure as "entrepreneurship" the number of people who are engaged in starting up a venture. This "controls for" the institutional differences that drive entrepreneurial talent to other activities. In that sense our model does not provide a formal test of the Baumol Hypothesis. Still, in the spirit of Baumol (1990), if the same level of entrepreneurial venturing yields different results in different regions, this difference may be attributed to institutions.

2. Background

2.1. Institutions and Growth

Institutions are the "humanly devised constraints that structure human interaction" (North, 1990, p. 97). The direct connection between institutions and economic growth has been addressed empirically by e.g. Easterly (2001), Acemoglu et al. (2000), Sokoloff and Engerman (2002) and Nunn (2008). There has also been a lot of important work done in this area with regards to theory building. The main problem in the Institutions and Growth literature is that institutions develop endogenously with economic growth, and therefore, to measure the effect empirically, the researcher has to find an exogenous instrument. But even if a satisfactory instrument can be found at the regional level, there is still the problem that no satisfactory measure of institutional quality exist. In fact, institutional quality is too elusive a concept to be measured. Proxies that have been used, such as indices of property rights protection and corruption, inevitably only "measure" a part of the relevant institutional complex en not even accurately so. This is reminiscent of the fundamental impossibility to measure "technical change" or "productivity growth". Ultimately growth empirics resorted to attributing the residuals in a growth regression to "total factor productivity growth". [4] Here we propose a similar strategy for "institutional quality". Different from productivity, however, institutional quality only indirectly affects output and growth. That is, assuming institutional quality matters for growth, its effects are somehow systematically correlated with unexplained growth, but institutional quality, almost by definition, works as a moderating variable on more proximate causes of growth. Entrepreneurial activity lends itself well to this approach, as the relationship between institutions and entrepreneurship is currently being researched extensively and the evidence suggests institutions seriously moderate the contribution of entrepreneurial venturing to growth (see below). As an example of this moderating mechanism, we could imagine that better protection of property rights increases the future gains from entrepreneurship, thereby attracting more entrepreneurial talent to start their own business (see e.g. Johnson et al. (1999), Sobel (2008)). Another example is an improvement of financial institutions, enabling a flow of funds from investors to potential entrepreneurs such that they can undertake larger and more ambitious projects, thereby also increasing the effect of entrepreneurial activity on growth (e.g. King and Levine (1993)). Informal institutions can also provide a moderating mechanism; trust, social capital and network are all likely to contribute to more productive entrepeneurship. Our approach thus distinguishes itself by researching a channel through which the indirect impact of institutions on growth will become visible through the contribution of entrepreneurship to growth. In the two next sections, we give an overview of the literature on entrepreneurship and growth, and on entrepreneurship and institutions.

2.2. Entrepreneurship and Growth

Theoretical interest in entrepreneurship and the link to economic growth goes far back. Schumpeter (1942) already put entrepreneurship centre stage by coining the term "creative destruction". In modern endogenous growth models, such as those developed by Romer (1986) and Lucas (1988), there is no role for entrepreneurship, as they passively commercialise all knowledge that is generated, but Aghion and Howitt (1992) created a model where entrepreneurs generate the knowledge and appropriate entrepreneurial rents through entry. Still, also in Aghion and Howitt (1992) knowledge creation and commercialisation are modeled as a single decision. Acs and Sanders (2012) deviate from modern growth literature by distinguishing between invention and innovation and show that in such a model entrepreneurship is complementary to knowledge creation and contributes to growth. The empirical evidence in support of these predictions, however, remains mixed. As Glaeser et al. (2010a, p.3) stated: "While it would be hard to imagine a world in which an abundance of entrepreneurs did not strengthen the local economy, the literature documenting this effect is still in its infancy". Empirical results are very inconclusive and mixed for three reasons. First, there is a measurement problem of entrepreneurship, which led to the use of many different proxies for entrepreneurship (Hechavarria and Reynolds, 2009; Stenholm et al., 2011). Studies using varying proxies for entrepreneurship (Audretsch, 1995; Carree and Thurik, 1998, e.g.) have found a positive relation

[4] This led Abramovitz (1956) to refer to it as "a measure of our ignorance". But we have made significant progress, explaining more and more of that residual, by relating variables one suspects to affect productivity, such as education and R&D, to this residual.

overall, but often these results are multi-interpretable. [5] Second, it was found that there is heterogeneity within entrepreneurial activity and that the effect on growth is not equal for all types of entrepreneurship (Santarelli and Vivarelli, 2007; Stam, 2009). Research makes a distinction between ambitious entrepreneurship or gazelles (Henrekson and Johansson, 2010) and businesses started at the local level that create little employment growth or economic expansion. Bowen and De Clercq (2008) then show that identifying the *type* of entrepreneurship, rather than the level, provides insight into the contribution of entrepreneurship to economic growth. Wennekers et al. (2005) find a U-shaped relationship between entrepreneurial activity and economic development. This finding was explained as labor moving from unproductive entrepreneurship into employment in early stages of development (higher GDP/cap reduces entrepreneurship) and from employment into growth enhancing innovative entrepreneurship (entrepreneurship causing GDP/cap growth) as development increases. The countries and regions in our dataset, however, are all on the higher ends of development, which would suggest a positive relation between entrepreneurial activity and economic growth. The inversion of the causality referred to above already indicates that reverse causation between economic growth and entrepreneurship makes the relation hard to disentangle empirically (Baumol, 1990; Carree and Thurik, 2010; Stephens and Partridge, 2011; Fritsch and Wyrwich, 2014, E.g.). This problem has been addressed differently by different authors.

As we are not primarily interested in the marginal effect of entrepreneurship itself, however, we can side-step this issue by letting the variations in institutional regime come latently from the data. We hope to make a convincing case that by controlling for common variance in regions in the same country as well as controlling for the usual suspects in our growth regressions, possible differences in the effect of entrepreneurship on growth are caused, *inter alia* by differences in the regional institutional regime, even if the estimated effect itself is biased. In addition, the endogeneity between economic growth and entrepreneurship is partially solved because our entrepreneurship variable is aggregated from 2001-2006, whereas we measure average growth in GDP between 1991 and 2009.

2.3. Institutions and Entrepreneurship

To analyse the effects of institutions one typically needs longer time series. As data on entrepreneurship has not been collected systematically until relatively recently, however, the empirical literature linking entrepreneurship and institutions is still emerging. Most studies to date have looked into how the institutional framework determines the level of entrepreneurial activity. Hechavarria and Reynolds (2009) test the influence of culture as a specific institutional characteristic, and find that it is a significant factor in predicting opportunity and necessity entrepreneurship rates at the country level. Arenius and Minniti (2005) and Freytag and Thurik (2007) stress the importance of entrepreneurial perceptions as a part of the local culture in order to stimulate productive entrepreneurship. At the country level, Henrekson (2005) found that welfare states institutions hamper entrepreneurship growth. The GEM 2011 global report (Kelley et al., 2011) also identifies institutions, or framework conditions in their terminology, as an important driving factor. The literature on institutions and entrepreneurship was largely inspired by Baumol (1990),who takes institutions as exogenously given. Douhan and Henrekson (2010) argues that we should regard institutions as endogenous. But whether institutions are taken as exogenous or endogenous, both authors agree that there is an indirect effect of institutions on economic growth, through the allocation of entrepreneurs over different types of activity. When looking at which institutions are most influential, some authors make a distinction between informal and formal institutions. Culture is then seen as a (local) set of informal institutions, as in North (1990). And within informal institutions one might distinguish between general regional culture, such as measured by Hofstede (1984) and Inglehart (1997) or specific attitudes towards entrepreneurship (Beugelsdijk and Noorderhaven, 2004). Other studies have looked into the effect of formal institutions and regulations on entrepreneurship rates and firm performance (Boettke and

[5] For example Glaeser et al. (2010b) and Carree and Thurik (1998) find a negative correlation between establishment size and employment or productivity growth, respectively. And one of the possible explanations is that small firms are a sign of more entrepreneurship and new startups. But there could be other explanations such as an increase in competition (Nickell, 1996; Nickell et al., 1997).

Coyne, 2003; Aidis, 2005; Capelleras et al., 2007; Webb et al., 2009; Stenholm et al., 2011). As we will analyse the importance of institutions at the regional level, we might follow Tabellini (2010) in assuming that all formal institutional dimensions are captured at the national level and consider the formal institutional environment to be more or less homogenous within countries.[6] Informal institutions, however, can still vary significantly within countries, especially in the attitudes towards entrepreneurship. This is supported by e.g. Mai and Gan (2007) who find that the regional cultural environment has a larger influence on perceived entrepreneurial opportunities than the national political environment. If we look at institutional quality as a latent variable, we should therefore look at the lowest possible aggregation level.

2.4. Regional Growth

We conclude from the above review that the relation between entrepreneurship and growth is found to be heterogeneous and not all types of entrepreneurship create economic growth to the same extent. Also, the institutional framework is shown to be crucial for the transformation of entrepreneurial talent into activity and ultimately economic growth. A hypothesis one might derive from that is that institutional quality moderates the effect of entrepreneurial activity on growth. And more specifically we investigate this hypothesis for regional growth.

Naturally some of the traditional growth models have been extended to the regional level. This means that in regional growth accounting, we expect capital formation as well as population growth to play a role, as in the neoclassical growth model. E.g. Sala-i Martin (1996) also finds evidence for beta-convergence between regions in the USA, Canada, Japan and Europe, indicating that initial income should be controlled for in a regional growth regression. However, the largest share of variance in growth across regions has been attributed to productivity differences and innovation. In empirical work on regional growth we can then distinguish i) the linear model ii) the innovation-systems or learning-region model and iii) the knowledge spillovers model.Rodríguez-Pose and Crescenzi (2008) are the first to have nested these models in one empirical specification. They find that knowledge spillovers indeed happen. But they also show that the transmission of tacit knowledge strongly decays with distance, supporting the innovation systems approach. Furthermore they find that R&D expenditures only lead to actual innovation and growth if a) a region can also benefit from extra-regional spillovers, measured by R&D in neighbouring regions and b) the territorially embedded institutional environment is conducive to the diffusion of innovation. These results can be related to the geographical clustering literature (Jaffe et al., 1993; Breschi and Lissoni, 2003; Bosma et al., 2008) that links the success of certain regions to the formation of a cluster within which companies of the same sector thrive and benefit from agglomeration advantages and knowledge spillovers. Frenken et al. (2007) show that such spillovers are stronger for "related varieties" in "smartly specialised" regional clusters. Reynolds et al. (1994) find that urbanisation promotes spillovers. A result that Bosma (2009) confirmed in a multilevel analysis for European regions as also presented in this paper. From the regional growth literature we take away that it makes sense to control for R&D efforts, population density, age structure and industry diversification.

2.5. Institutional Regimes

The above contributions lead us to the hypothesis that at the regional level entrepreneurship should be expected to positively correlate with growth. There are, however, also reasons to expect this effect to differ across regions. (Helsley and Strange, 2011) for example show that urbanised cultures are often more conducive to growth-oriented entrepreneurship. When looking at regional performance in general, Eriksson et al. (2013) have distinguished between regions with a 'business climate' and regions with a 'people climate', finding that both matter for regional performance, but through different channels. Audretsch et al. (2012) classify regions in an explicit way, using the functional specialisation theory. In a sample of German regions they use regional characteristics to determine the industry structure, and thereby the specialisation

[6] Arguably, across our EU-regions, there is even a large degree of formal institutional harmonisation across regions in different countries.

into either production or innovation. They find five groups of regions, Industrial Districts, Periphery, Industrial Agglomeration, Urban Agglomeration and Urban Periphery. The propensity to start a business is highest in group 1, 4 and 5, and these types of regions are thus said to have an entrepreneurial regime. These papers, however, focus entirely on the effects of the institutional environment on entrepreneurial activity. In this paper we investigate if there are latent regional institutions that do not only determine the propensity to start a business but also the contribution to growth of such early stage entrepreneurship.

3. Empirical Strategy

We thus aim to measure the contribution of entrepreneurship to economic growth and see if and how that contribution is moderated through (latent) institutional variables. We will analyse the effect of institutions through entrepreneurship on growth using a three-step process. First we estimate a standard growth regression (Mankiw et al., 1992) extended with entrepreneurship and some regional controls in a pooled OLS estimation to establish the effect of entrepreneurship on growth at the regional level. Next we estimate this model in a multilevel specification. Estimating this in a multilevel model allows us to distinguish between variance in growth rates at the regional and national level, and the extent to which entrepreneurial activity can account for this variance. We then take our entrepreneurship variables out and reestimate both models saving the growth residuals. We then regress these residuals on our entrepreneurship variable in an unconditional latent class specification. That allows us to test the hypothesis that the marginal contribution of entrepreneurship to (unexplained) growth differs systematically between (groups of) regions that do not necessarily coincide with countries.

The growth literature has emphasised the importance of considering all relevant variables in a growth regression (Martin, 1997). We base our model on the Mankiw et al. (1992), hereafter MRW model and we estimate a cross-regional growth regression including the "usual suspects", adding also relevant regional controls. The regression equation can be derived from the production function:

$$Y(t) = K(t)^{\alpha} H(t)^{\alpha} (A(t)L(t))^{1-\alpha-\beta} \tag{3.1}$$

where Y is output, K is capital, L is labour, H is the stock of human capital and A is the level of labour augmenting technology. [7] From this specification we can derive (see Appendix) the MRW specification for a 2001-2009 regional growth regression:

$$\frac{lnY_i(2009) - lnY_i(2001)}{9} = \alpha_0 + \alpha_1 s_i^k + \alpha_2 s_i^h + \alpha_3 n_i + \alpha_4 lnY_i(2001) + \epsilon_i \tag{3.2}$$

where i indexes regions, s_i^k and s_i^h are the shares of income invested in human and physical capital respectively, n is the growth rate of the population and we control for initial income to test for convergence. The advantage of this specification is that regions are allowed to be out of the steady state. The disadvantage is that permanent productivity differences in the production function, $A_i(0)$, across countries and regions end up in the error term. We will control for these differences by estimating the country effect in a multilevel model.

$$\begin{aligned} &\frac{lnY_{ij}(2009) - lnY_{ij}(2001)}{9} = \\ &\alpha_0 + \alpha_{0j} + \alpha_1 (s_{ij}^k + \alpha_2 s_{ij}^h + \\ &\alpha_3 n_{ij} + \alpha_4 lnY_{ij}(2001) + \\ &+ \epsilon_{ij} \end{aligned} \tag{3.3}$$

[7] In a Cobb-Douglas it does not matter if we specify technology as purely labour augmenting, purely capital augmenting or as total factor productivity as the elasticity of substitution is 1. This is easily verified by defining $B_i \equiv A_i^{1-\alpha-\beta}$, where B_i is then total factor productivity.

where j indexes the country and the specification allows for country specific intercepts α_{0j}. Residual variation, ϵ_{ij}, can also be decomposed a fixed and a random part, which are used to calculate between and within country variation using the Intra Class Correlation (ICC) (Snijders and Bosker, 2012).

To establish the effect of entrepreneurship on growth at the regional level we first extend the pooled OLS growth regression by adding the entrepreneurial variables of interest. The regression equation that we estimate becomes:

$$\frac{lnY_i(2009) - lnY_i(2001)}{9} = \alpha_0 + \alpha_1 s_i^k + \alpha_2 s_i^h + \alpha_3 n_i + \alpha_4 lnY_i(2001) + \alpha_5 E_i + \epsilon_i \quad (3.4)$$

where E_i is our proxy for entrepreneurship [8]. By comparing the results from this regression to a multilevel specification (that is equivalent to the one in equation 3.3 but we do not write out to save on notation), we can test the hypothesis that the marginal effect of entrepreneurship on growth, controlling for the usual suspects, is different across countries and/or regions within countries. By taking the residuals from regressions 3.2 and 3.3 and regressing these residuals on regional entrepreneurship in a latent class specification that allows for endogenous sorting into regimes $r(=1,...R)$.

$$\begin{aligned} \epsilon_i &= \beta_{0r} + \beta_{1r} E_i + \varepsilon_i \\ \epsilon_{ij} &= \beta_{0r} + \beta_{1r} E_{ij} + \varepsilon_{ij} \end{aligned} \quad (3.5)$$

where $r = 1, ..., R$ indicates the regime and R refers to the (exogenous) total number of regimes. Each regime has its own parameter vector β. In other words, β_0, β_1 are allowed to differ across regimes, r. We can then test for the existence of latent classes in the data following Greene (2007) who suggests a "test-down" strategy to identify the correct number of regimes. By regressing the residual on entrepreneurship only, we restrict this analysis to finding groups of regions that differ in the marginal contribution of entrepreneurship to unexplained, residual growth variation. It should be noted that the estimated coefficients are likely to be biased by endogeneity (entrepreneurship is endogenous to GDP growth) and omitted variable bias (our specification is parsimonious and variables, possibly correlated with institutional quality, such as religion and geography, are not included). At this stage, however, we are primarily interested in the possible clustering of data points the latent class model would suggest. In the next section we will describe our data and present our results.

4. Data and Results

4.1. Data

Our data comes from Eurostat (2013) and GEM (2013), as is described in table 1. Our unit of analysis is the region. We therefore collected data on 90 NUTS-2 and some NUTS-3 regions in 16 European countries. We collected data on GDP and the variables in the MRW growth regression for the period 1991 and 2009, or as long as our datasources allowed.

We have regional GDP data for each year between 1991 and 2009, and take the logarithmic average growth rate, ΔlnY. We also take the logarithm of initial GDP, which is from the year 1991, $lnY(1991)$. For the share of physical capital investment in income, s^k, we take the average of annual investment rates, so the ratio of gross fixed capital formation to GDP.[9] For the investment in human capital, s^h, MRW propose a variable "school", which is formed by multiplying the fraction of the 12-17 aged population that is enrolled in secondary school by the fraction of the working-age population that is of school age, as actual investment in human capital is hard to obtain. This variable could be seen as foregone earnings on the part of the working-age population that is in school. For most European regions, however, secondary education is obligatory until the age of 16 or 17, so we do not expect much variation there. Therefore, we take the share

[8] We test three.

[9] For all the averaged variables, we take the average of all available years in the sample period for that region.

Table 1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N	Unit	Year	Source
ΔlnY	2.152	0.824	0.436	5.069	90	% per annum	1991-2009	Eurostat
			(DE: Berlin)	(IE: Border, Midlands and Western)				
$lnY(1991)$	10.559	1.07	8.161	12.721	90	Natural log of Mln 1999 EUR	1991	Eurostat
			(HU: Southern Transdanubia)	(FF: Ile de France)				
s^k	0.208	0.052	0.097	0.321	90	per GDP	1995-2009	Eurostat
			(HU: Southern Transdanubia)	(GE: Thüringen)				
s^h	5.562	1.868	2.612	12.422	90	% of population	2000-2009	Eurostata
			(DE: Brandenburg)	(BE: Brussel)				
n	0.332	0.458	-0.945	1.734	90	% per annum	1992-2009	Eurostat
			(DE: Sachsen-Anhalt)	(ES: Murcia)				
$R\&D$	1.517	1.15	0.138	5.576	90	Mln 1999 EUR	1991	Eurostat
			(GR: Central greece + Ionian Islands)	(SE: Övre Norrland)				
DIV	0.073	0.049	0.022	0.254	90	Index	2000	Dogaru et al.
			(GE: Schleswig-Holstein)	(SE: Övre Norrland)				
YNG	0.362	0.037	0.265	0.454	90	% of population	2000	Dogaru et al.
			(UK: Scotland)	(ES: Murcia)				
$NEIGH$	2.164	0.583	1.054	5.069	90	% per annum	1991-2009	Eurostat
			(DE: Hamburg)	(UK: Northern Ireland)				
TEA	5.155	1.507	1.861	9.699	90	$\%of population$	2001-2006	GEM
			(FR: Center-East)	(DE: Hamburg)				
TEA_{in}	0.871	0.419	0.097	2.664	90	$\%of population$	2001-2006	GEM
			(PT: Norte)	(DE: Hamburg)				
TEA_{hj}	0.663	0.392	0.063	2.634	90	$\%of population$	2001-2006	GEM
			(FR: Parisien Bassin)	(DE: Hamburg)				

Eurostat data are taken from Eurostat (2013). GEM data from GEM (2013) of the working-age population aged 20-24 and multiply it by enrolment rates in tertiary education (ISCED 5-6) as % of the population aged 20-24. For n we take the logarithmic average population growth. We do not include g or δ, as these are assumed to be constant across countries in MRW. That assumption then holds *a fortiori* for EU-regions and including these constants is only important if the actual size of the estimated coefficients is of interest. We are mostly interested in the between regional variation in the marginal effect of entrepreneurship, which is unaffected by the constant and so we dropped these variables.[10]. We test three measures of entrepreneurship as the literature suggests not all types of entrepreneurship make a contribution to growth. Our entrepreneurship variables are taken from the Global Entrepreneurship Monitor (GEM) (GEM, 2013), that measures Total Entrepreneurial Activity (TEA) as the share of people who answered yes to the following question: "Are you involved in early-stage entrepreneurial activity?". GEM also considers various subcategories of which two are of particular interest for our purpose. For innovative entrepreneurship (TEA_{in}), GEM takes only the entrepreneurs who indicated to be involved in either a new product or a new product-market combination. For entrepreneurs with a high job growth orientation (TEA_{hj}), GEM takes only those early stage entrepreneurs who answered yes to the question 'Do you expect to have 20 or more jobs in your company in the next 5 years?'. Entrepreneurship of different types can than be estimated by extrapolating from this nationally representative survey. To obtain reliable results at the regional level, however, Bosma (2009) suggested to compute regional shares over 6 waves of the GEM between 2001-2006 for our European regions. The correlations between these variables are displayed in table 7 in the appendix. Finally, we added some controls from Dogaru et al. (2011) and Thissen et al. (2011) that have been proposed in the regional growth literature. We also added the variable $NEIGH$ which represents the average growth of a region's neighbors, i.e. the regions with which it shares a land-border. The maximum value of NEIGH is equal to the maximum value of our actual GDP growth variable, this is because the region with the highest growth (Ireland: Border, Midlands and Western) only has one neighboring region in this sample.

These include population density (PDN), regional R&D ($R\&D$), an index of regional diversification over industries (DIV)[11] and the share of young people between 18 and 34 in the population (YNG). We see that the variation in GDP growth rates is large and that all variables fall in the expected range. There were no outliers deleted and all variables are reasonably normally distributed. Furthermore, in the correlations table in the Appendix we can see that there is a significant negative correlation between the GDP in 1991 and the GDP growth rate over the whole period, suggesting a convergence effect. From the usual suspects, only population growth has a significant and positive correlation with GDP growth. All three entrepreneurial variables have a significant and positive correlation as well. Naturally, the three types of entrepreneurship are also highly correlated amongst each other. However, we cannot interpret these correlations as causal relations, as interdependencies between regions in the same country are not accounted for yet and causality in these variables is very likely to run both ways. This will bias the estimated coefficients later on, but should not affect our results on between country or region differences in the correlation coefficients of entrepreneurship with growth.

4.2. Estimation

We first regress all of the variables of interest on GDP growth during the entire period in a standard pooled OLS regression, following the specification from the MRW model. The results are displayed in table 2 below. The standard pooled OLS regression (model 1) shows that there is convergence within the set of European regions between 1991 and 2009. However, convergence disappears when we extend the model with regional controls, which is in line with the findings in Rodríguez-Pose and Crescenzi (2008). As our correlation table already suggested, the rate of population growth has a positive effect on the average GDP growth rate. But again, we cannot claim any causality from this finding. It could for example be that fast growing regions also attract more migrants, explaining this positive effect. s^h does not have a

[10] More precisely, this gets absorbed in the constant in our regressions

[11] The degree of regional specialization is measured by the Theil index over the location quotients of 59 products including agriculture, manufacturing and services, for the year 2000. This variable is further described in Dogaru et al. (2011) and Thissen et al. (2011). It actually measures specialization, so a high score means high specialization and thus low diversity.

significant effect on growth rates. This might be explained by the fact that human capital is high in all European regions, and therefore the explanatory power of higher tertiary education on growth is not large. Investment is positive, but not significant in the initial MRW model, but it is significant in all other extended models. The number of observations has dropped from the original sample of 128 to 90, because not all variables could be obtained for all the regions in our sample. The regions that fell out are mainly regions that consist of only a city, so below the standard NUTS-2 regional level, as well as some countries as a whole.

Table 2: OLS Regression of MRW model with regional controls and entrepreneurship

$\Delta lnY(1991-2009)$	1	2	3	4	5	6
$lnY(1991)$	-0.240**	-0.078	-0.070	-0.105	-0.087	-0.148
s^k	2.581	4.385**	4.421**	4.405**	4.658**	4.308**
	(1.87)	(1.97)	(1.98)	(1.95)	(1.99)	(1.99)
s^h	-0.027	-0.038	-0.038	-0.028	-0.031	-0.023
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
n	0.495***	0.565***	0.556***	0.505**	0.582***	0.508**
	(0.19)	(0.21)	(0.21)	(0.21)	(0.21)	(0.22)
$R\&D$		0.040	0.040	0.010	0.028	-0.003
		(0.07)	(0.07)	(0.07)	(0.07)	(0.08)
DIV		1.888	2.087	1.845	2.257	1.149
		(2.32)	(2.39)	(2.29)	(2.35)	(2.43)
YNG		-2.382	-2.609	-2.336	-2.880	-1.545
		(2.68)	(2.76)	(2.64)	(2.72)	(2.82)
$NEIGH$		0.531***	0.520***	0.486***	0.518***	0.502***
		(0.14)	(0.15)	(0.15)	(0.15)	(0.15)
TEA			0.022			-0.077
			(0.057)			(0.080)
TEA_{in}				0.343*		0.506*
				(0.194)		(0.298)
TEA_{hj}					0.218	0.017
					(0.212)	(0.323)
Cons.	4.135***	1.602	1.489	1.677	1.653	2.119
	(1.33)	(1.88)	(1.92)	(1.86)	(1.88)	(1.93)
R-squared	0.193	0.323	0.324	0.349	0.321	0.357
Adj. R-squared	0.156	0.256	0.248	0.257	0.256	0.266
N	90	90	90	90	90	90

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We also ran the pooled OLS regression adding several controls from the regional growth literature (model 2). The first regional control is money spent on R&D, both public and private ($R\&D$), to proxy for innovative effort. Second we include an index of how diversified a region is across sectors (DIV), to accommodate for the portfolio effect. Third, we include the share of the working age population that is between 18 and 34, to take into account the demographic structure of the region (YNG), similar to the proxy used in Rodríguez-Pose and Crescenzi (2008). And fourth we include the average growth rate of neighbouring regions (both within the same country and across national borders where applicable).

When including these regional control variables, the convergence effect disappears and investment instead becomes significant. However, the regional control variables are themselves not significant, except for the neighbour region growth, replicating a well-known result in regional growth empirics and suggesting significant spillover effects. This is in line with the findings of (Rodríguez-Pose and Crescenzi, 2008), who also showed that e.g. life-long learning, the percentage of the labour-force working in agriculture, and the demographic structure of the population are not significant in explaining growth in European regions during roughly the same period as we study. Jointly, the four regional controls are significant, but when excluding neighbour region growth from the F-test, the remaining 3 variables are not jointly significant.

We then include our proxies for entrepreneurship. The variables suggested by MRW are long term averages, whereas our measures of entrepreneurship are taken between 2001 and 2006. We argue that our measure of entrepreneurship is a reasonable proxy for the long run level of entrepreneurship as there is high persistence in start-up rates (Fritsch and Mueller, 2007; Brenner and Fornahl, 2008; Andersson and Koster, 2011). This was also the justification for the GEM to merge data between 2001 and 2006 (Bosma, 2009). According to Fritsch and Mueller (2007), the theoretical rationale behind this lies in the regional culture of entrepreneurship that can survive even when supportive infrastructure is destroyed (like in big wars or conflicts). Adding our entrepreneurship measures into the MRW model does not change the estimated coefficients a lot. Only innovative entrepreneurship (TEA_{in}) is significant when added individually to the model. When all three are added at the same time, again only innovative entrepreneurship survives with a positive and significant sign. An F-test shows that the three entrepreneurship variables are not jointly significant in this last specification. Adding the different entrepreneurship variables to the standard MRW specification explains an extra 3% of the unexplained variance. The large difference in the size of the coefficients between TEA on the one side and TEA_{in} and TEA_{hj} on the other side is caused by the fact that the latter two are subsets of the first variable. A one percent point increase in one of these two variables will thus be a rarer case than a one percent point increase in the total early stage entrepreneurs. Finally, we note that investment in physical capital remains significantly positive in specifications where entrepreneurship variables are added. Tentatively one might conclude that physical capital investments and entrepreneurship thus contribute through different channels to regional growth.

The results obtained from the pooled OLS estimations above, are, however, not to be taken at face value. Contrary to the cross-country analysis of MRW, we have regions in countries and this creates two problems; first of all, cross country variation in the production function will now be absorbed in the constant and residuals, which is something that we do not want. Furthermore, the assumption of identically and independently standard errors will be breached when regions in country A all suffer from lower productivity relative to regions in country B. To incorporate country effects, we will therefore estimate our model in a multilevel regression, estimated using restricted maximum likelihood estimation, because this gives the most unbiased estimates when the sample size is small. In this multilevel specification we allow the intercept, and thus the mean growth rate, to vary between countries. We tested the standard linear model against the varying-intercept model for all specifications and the Likelihood Ratio test statistics show that the country multilevel model should be preferred, both including and excluding entrepreneurship proxies. For the standard MRW model, without entrepreneurship proxies, we also tested whether a varying-slope model should be used. This model was rejected in favour of the varying-intercept model.

The results from the multilevel growth regression are presented in table 3. For all models we have 90 observations in 14 countries with an average of 6.4 regions per country between 1 (Ireland) and 14 (Germany). We first present the MRW model in a multilevel specification (model 1), the convergence effect is no longer significant. This means that in the time period studied, regions grew closer together, but this was not true for regions within the same country. Population growth still has a positive effect, and investment is now positive in all specifications.
Table We use the Akaike Information Criterion (AIC), a measure based on the log-likelihood of the model, to see which model is preferred. The standard MRW-model is the model with the lowest Akaike Information Criterion (AIC), which means that within this range of nested models, it is the model with the best fit. This means that neither regional controls nor entrepreneurship measures can significantly improve upon the standard growth model within this sample. We will still look into the results a little deeper, as the multilevel specification allows us to see whether the added variables explain more level 1 or level 2 variation. The ICC measures the Intra Class Correlation (Snijders and Bosker, 2012), the degree of similarity between

Table 3: Multilevel models

$\Delta lnY(1991-2009)$	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Fixed Effects							
$lnY(1991)$		-0.016	0.020	-0.014	0.019	0.013	-0.052
		(0.13)	(0.14)	(0.13)	(0.14)	(0.14)	(0.14)
s^k		14.139***	12.091***	10.470***	12.101***	11.815***	9.726***
		(2.82)	(2.90)	(2.79)	(2.96)	(2.91)	(2.85)
s^h		0.002	-0.016	-0.018	-0.016	-0.017	-0.016
		(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
n		0.495***	0.487**	0.457**	0.489**	0.492**	0.470**
		(0.19)	(0.21)	(0.22)	(0.22)	(0.21)	(0.22)
$R\&D$			0.038	0.027	0.038	0.034	0.019
			(0.07)	(0.08)	(0.07)	(0.08)	(0.08)
DIV			1.738	1.742	1.721	2.077	1.548
			(2.91)	(2.80)	(2.93)	(2.88)	(2.91)
YNG			-0.315	-1.258	-0.234	-1.103	-0.807
			(2.90)	(2.88)	(3.03)	(3.05)	(3.09)
$NEIGH$			0.296**	0.328**	0.295**	0.314**	0.344**
			(0.14)	(0.15)	(0.15)	(0.15)	(0.15)
TEA_{in}				0.254			0.383
				(0.221)			(0.335)
TEA					-0.005		-0.076
					(0.065)		(0.085)
TEA_{hj}						0.160	7.032
						(0.249)	(0.367)
Cons.	2.160***	-0.764	-1.340	-0.560	-1.336	-1.078	0.029
	(0.13)	(1.773)	(2.003)	(1.992)	(2.036)	(2.010)	(2.060)
Random Effects							
Var (cons)	0.116	0.718	0.567	0.493	0.574	0.524	0.416
	(0.115)	(0.211)	(0.241)	(0.270)	(0.242)	(0.242)	(0.247)
Var (resid)	0.588	0.605	0.624	0.643	0.628	0.633	0.652
	(0.010)	(0.053)	(0.059)	(0.065)	(0.059)	(0.061)	(0.064)
Model Fit Statistics							
ICC	0.165	0.585	0.452	0.318	0.456	0.407	0.289
AIC	225.618	**210.234**	211.623	213.787	217.264	214.189	220.352

Standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

two regions that are in the same country, or alternatively the share of the variance that can be attributed to differences at the country level. The Var(cons) is the estimated variance that is attributable to level 1 (countries in our case), while the residual variance is the variance at the lowest level, so the regional level in our case. When the former is significantly different from zero, this implies country level differences are significant. From our ICC we see that adding entrepreneurship variables decreases the share of variance that is 'between countries', except for the model with only TEAYY included, where the ICC remains roughly the same as in the MRW model with regional controls. Entrepreneurship thus picks up variance at the country level, while the variance at the regional level remains roughly equal. This means that the usual suspects in growth regressions as well as the entrepreneurship variables are relatively more successful in explaining between-country variation than within-country variation. When looking at the economic significance of the coefficients in our final model, we can compare the product of the coefficients of the significant variables and their respective standard deviation to the standard deviation of GDP growth. The standard deviation of GDP growth is 0.824. The economic effect of s_k is 0.506, that of n is 0.216 and that of $neigh$ is 0.201. So when investment is increased by one standard deviation, GDP growth increases by a little bit less than a standard deviation.

What we also want to investigate is whether the effect of entrepreneurship varies between regions inside countries. We will do this only for entrepreneurship with high job growth orientation, as this was the model with the best fit and it was the only model that significantly improved on the standard MRW model in table 3. A first way to measure the possible interaction effect is to add the country-level mean of high-job growth entrepreneurship to the model, as well as the interaction effect between a country's average entrepreneurship rates and the region's deviation from that mean. This means that entrepreneurship may have a more positive effect on economic growth in regions in countries where entrepreneurship is generally high.

Table 4 shows how the multilevel model is built up. Model 1 is the empty model, with just the intercept. This model shows (again) that the average GDP growth rate over this period is 2.16%. And again we have 90 observations in 14 groups of minimum 1 and maximum 14 and average 6.4 regions per country.

In the second model, we add the mean rate of innovative entrepreneurship per country to the model, in order to explain some of this country-level variation. The intercept, which now corresponds to the GDP growth rate in a country with average entrepreneurship levels, is 1.461%. A one percent increase in the average innovative entrepreneurship rate is associated with an increase of the GDP growth level of 0.831%. Adding the mean rate of entrepreneurship to the multilevel model increases the ICC, the share of the variance that is within countries, and this is logical because we added a country-level explanatory variable. When adding our regional controls, the ICC goes up, but this is mainly because the residual variance (at the regional level) is decreased through these regional-level variables. so again this makes sense.

In the third model we add the regional entrepreneurship rate, centered around the country mean, together with the interaction effect with the country-mean entrepreneurship rate. This interaction is not significant, meaning that entrepreneurship does not have a larger effect in regions in countries with higher entrepreneurship rates. In the final model, we added all other variables, which leads to the model with the lowest AIC so the best fit. We conclude that, while the country-level mean entrepreneurship remains significant, the region's (centered) entrepreneurship rate is not. This means that most of the effect of entrepreneurship on regional economic growth, controlling for the usual suspects, works through the average level of entrepreneurship in countries.

We obtained the same results when we add the group mean of total entrepreneurial activity or high job growth entrepreneurship in this multilevel regression; the effect of the entrepreneurship is nonsignificant but the effect of the group mean of the variable is large and positive.[12] Therefore we may conclude that adding entrepreneurship rates to a growth regression helps explain regional GDP growth, but at the between-country level. Our multilevel specification, however, will not pick up systematic differences between regions that cluster on another grouping than countries. One might, for example, think of urban and

[12]Not presented here. Results available upon request.

Table 4: Multilevel model with Fixed and Random Effects

Fixed Effects	Model 1	Model 2	Model 3	Model 4
Cons.	2.160***	1.461***	1.456***	-2.164
	(0.13)	(0.34)	(0.33)	(1.95)
TEA_{in} (mean)		0.832**	0.839**	1.110***
		(0.369)	(0.364)	(0.407)
TEA_{in} (centered)			1.546	0.728
			(1.399)	(0.123)
TEA_{in} (mean*centered)			-1.199	-0.583
			(1.358)	(1.197)
$lnY(1991)$				0.013
				(0.13)
s^k				12.446***
				(2.78)
s^h				0.020
				(0.05)
n				0.439**
				(0.21)
$R\&D$				0.024
				(0.07)
DIV				0.816
				(2.88)
YNG				-0.702
				(2.87)
$NEIGH$				0.257
				(0.14)*
Random Effects				
Var(Cons)	0.341	0.375	0.365	0.484
	(0.169)	(0.154)	(0.151)	(0.192)
Var(TEA_{in}(centered))			0.394	0.332
			(0.496)	(0.341)
Var(resid)	0.767	0.742	0.739	0.608
	(0.064)	(0.062)	(0.062)	(0.055)
Model Fit Statistics				
ICC	0.308	0.336	0.331	0.443
AIC	225.615	222.850	226.561	**211.078**

rural regions, industrial or agricultural or larger regional clusters such as Scandinavian, North-Western, Southern and Eastern EU-regions. To get at such clusterings we employ a latent class model.

4.3. Latent Class Analysis

From the standard MRW model, excluding entrepreneurship, we can take the residuals and then save these as a measure of 'unexplained growth'. We know from our analysis above that entrepreneurship has some explanatory power, but so far we were unable to establish a strong link at the regional level. The objective here is to find out if the contribution of entrepreneurship to this residual growth is different across classes of regions. We can use residuals from the OLS model, so that we do not control for country effects, or from the multilevel model, so that we do control for country effects. We then regress these two measures for unexplained growth on our three measures of entrepreneurship and test for the existence of multiple regimes in our sample. Graphs 1, 2 and 3 show the bivariate relation between residual GDP growth (from the multilevel model) and total early stage entrepreneurship, innovative entrepreneurship and job-growth oriented entrepreneurship, respectively.

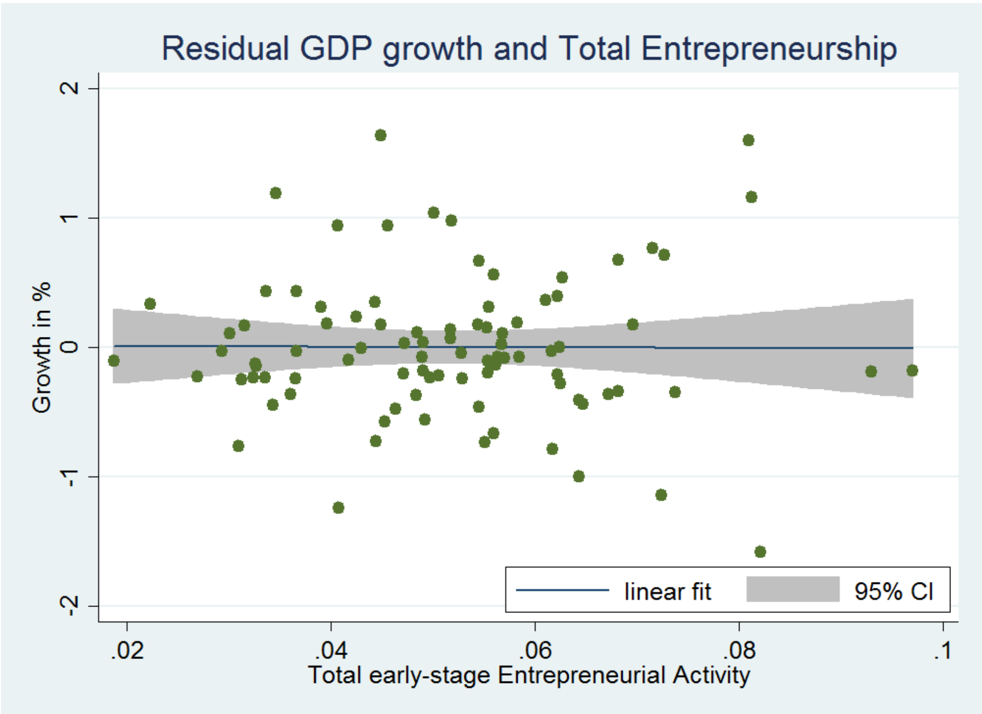

Figure 1: Relation between Total Early Stage entrepreneurial activity and economic growth

For the OLS residuals, the bivariate correlation between unexplained growth and innovative entrepreneurship is 17.7% and this is a significant correlation. For total early stage entrepreneurship and job-growth oriented entrepreneurship, respectively, the correlations are 3.7% and 10.4%, both not significant. With regards to the multilevel residuals, the residuals for total early stage entrepreneurship, innovative entrepreneurship and job-growth oriented entrepreneurship are -0.6%, 7.1% and 4.6%, but all of these are not significant.

However, it might still be that even though the total, homogeneous effect is insignificant, we can find one or more classes in which there is a positive and significant relation between innovative entrepreneurship and (unexplained) GDP growth. Furthermore, if would like to show any effect of institutional regimes

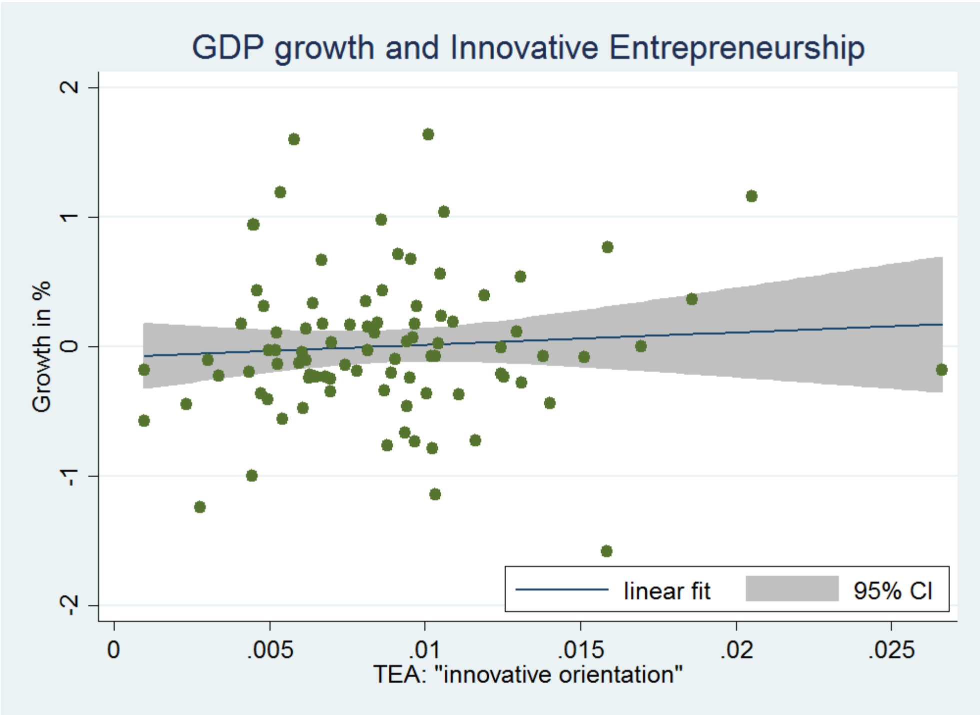

Figure 2: Relation between Total Early Stage entrepreneurial activity and economic growth

on regional growth on top of the standard growth regression, then we need to show that this heterogeneity is indeed present in the data. Therefore, we run three latent class analyses on the normalized growth residuals[13], using total entrepreneurship, then innovative entrepreneurship and then job-growth oriented entrepreneurship as explanatory variables. We compare models with 1, 2, 3 and 4 classes on the base of three information criteria. The model that scores the lowest values on these criteria is to be preferred (see table 5 and 6).

We see that regressing the multilevel residuals on TEA, TEA_{in} and TEA_{hj}, one class is preferred. For the OLS model residuals the model selection criteria show that for all three explanatory variables, the model with one class is preferred. We also tested a model with only a constant, but also in that case one class is preferred. Therefore, we cannot reject the hypothesis that the marginal effect of entrepreneurship on unexplained growth is homogenous, both controlling and not controlling for country fixed effects.

5. Discussion

The main idea in this paper was that the effect of entrepreneurship on growth could be different for different 'institutional regimes' across European regions. However, the hypothesis of a homogeneous effect for all regions in the sample could not be rejected. Using the standard MRW growth model, controlling for additional regional variables and shared country variation in a multilevel model, we find that investment in physical capital and population growth have a positive effect on regional growth in European regions between 1991 and 2009. There is also a spillover effect, meaning that neighbour regions' average income growth has a positive and significant effect on GDP growth. Investment in human capital and R&D are not

[13]We normalised the residuals so that they range from 0 to 1, this makes it easier for the model to converge

Table 5: Selecting Regimes - Multilevel Residuals

TEA	Log-likelihood	Obs	Parameters	AIC	Entrepreneurship significant in class 1, 2, 3, 4
1 class	29.987	90	2	**-3.459**	No
2 classes	37.094	90	7	0.669	No, No
3 classes	37.091	90	11	-0.579	No, No, No
TEA_{in}					
1 class	30.212	90	2	**-3.465**	No
2 classes	35.879	90	7	-0.642	No, No
3 classes	36.886	90	11	0.575	No, No, No
TEA_{hj}					
1 class	30.081	90	2	**-3.462**	No
2 classes	35.824	90	7	-0.641	No, No
3 classes	37.044	90	11	-0.579	No, No, No
$Constant$					
1 class	29.985	90	1	**-3.482**	
2 classes	36.843	90	5	-0.708	
3 classes	37.039	90	8	-0.645	

Table 6: Selecting Regimes - OLS Residuals

TEA	Log-likelihood	Obs	Parameters	AIC	Entrepreneurship significant in class 1, 2, 3, 4
1 class	35.423	90	2	**-3.581**	No
2 classes	37.658	90	7	-0.681	No, No
3 classes	39.512	90	11	-0.634	No, No, No
TEA_{in}					
1 class	36.804	90	2	**-3.611**	+, $p<0.10$
2 classes	38.078	90	7	-0.691	No, No
3 classes	39.364	90	11	-0.630	No, No, No
TEA_{hj}					
1 class	35.847	90	2	**-3.590**	No
2 classes	37.498	90	7	-0.678	No, No
3 classes	38.818	90	11	-0.618	No, No, No
$Constant$					
1 class	36.360	90	1	**-3.601**	
2 classes	37.445	90	5	-0.721	
3 classes	38.024	90	8	-0.667	

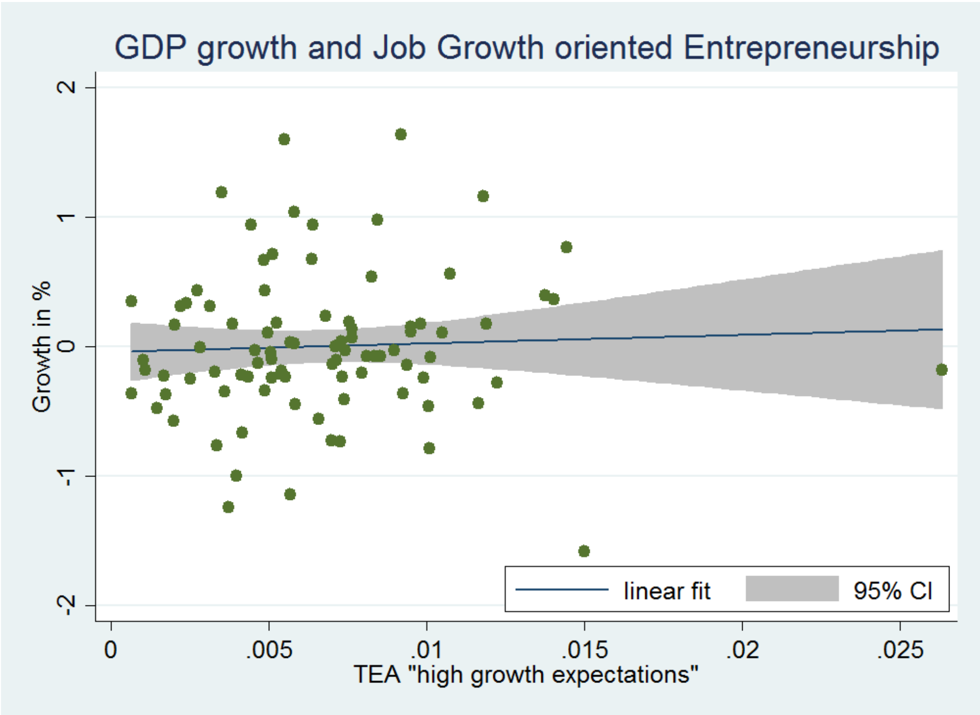

Figure 3: Relation between Total Early Stage Job Growth oriented entrepreneurial activity and economic growth

significant at the regional level once these factors are taken into account. Introducing entrepreneurship in the regression gives us a positive and significant effect for innovative entrepreneurship that remains significant even when all measures are introduced. In our multilevel estimations innovative entrepreneurship is no longer significant as a homogeneous effect. However, although regional entrepreneurship cannot help explain regional GDP growth in our model, the country average level of entrepreneurship does help explain regional GDP growth. This is another indication that spillover effects are important at the European within-country regional level. We also cannot show evidence for heterogeneous effects of entrepreneurship among groups of regions, so we do not find evidence for a moderating effect of regional institutions. A latent class estimation of growth residuals on all types of entrepreneurship confirmed this result. The effect of latent (informal) regional institutions on the relationship between entrepreneurship and growth has thus not become visible in our analysis. The homogenous marginal effect suggests that regional institutions in European regions are either not that different or matter little for the contribution innovative entrepreneurs make to regional economic growth. National level institutions seem matter more, but their effect also does not moderate the contribution of entrepreneurship. The fact that the country-average level of entrepreneurship matters for regional growth indicates that perhaps the high mobility of capital and persons in Europe evens out heterogeneous effects.

We carried out several robustness checks on our estimations. We changed the end time of the period to either 2006, 2007 or 2008, because of the possible disturbing effect of the financial crisis. This did not change the signs, significance or order of magnitude of any of the coefficients. We also tried alternative specifications to control for the country effect, respectively a varying-coefficient multilevel model and a standard OLS regression with clustered standard errors by country or country dummies. Both models were rejected in favour of the varying-intercept model presented above.

Although the literature strongly argues for a heterogeneous effect of entrepreneurship, and an interaction effect between entrepreneurship and institutional quality on economic growth, we cannot confirm this in our empirical analysis. We do not find an effect of regional entrepreneurship, but if a region finds itself in a country with high average entrepreneurship rates, this has a positive effect on regional growth. The fact that we do not find an effect of regional entrepreneurship, also not entrepreneurship with an innovative focus, might come across as striking. This result may corroborate earlier findings. E.g. Van Oort and Bosma (2012) found that at the regional level, innovation-oriented entrepreneurship was an important factor in explaining labor productivity. However, this study looks at labour productivity and not regional GDP growth. To our knowledge there has not been a study relating innovative entrepreneurship to economic growth, as research has only focused on the specific effects of high growth potential entrepreneurship (Wong et al., 2005) or Opportunity-oriented entrepreneurship (Hechavarria and Reynolds, 2009).

The second finding is the fact that we could not reject the hypothesis of a homogeneous effect of entrepreneurship. This, however, is not the same as rejecting the hypothesis of a heterogeneous effect. There may be a variety of reasons why our result was found. First, the sample under study might not be broad enough to find a heterogeneous effect. That is, the regions we studied may simply not be different enough to find significantly different marginal effects. The period under study is also a short period when compared to other empirical growth studies. Furthermore, the countries in the sample are all developed and very much integrated countries, which decreases the variation in growth rates. Finally, during the last years of the sample period, European regions have largely suffered from a financial crisis, affecting growth rates.

An important limitation of this study is the fact that we used data at the administrative NUTS2 level. While in some countries these regions largely coincide with the actual provinces or states, these regions are often quite meaningless in terms of informal institutions. Furthermore, the size and relative size of NUTS2 regions differs quite a lot. We feel that it would be meaningful to investigate this same model at a lower regional classification, however, as of now this is not possible due to data limitations (especially for investment in physical capital). We still feel that the effect of institutions on growth through entrepreneurship is a very important and relevant one. The challenge remains to make it visible in the data. With new, better and more complete data our method may allow us to do so in future research.

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Appendix

Derivation of Equation 3.2
Starting form the production function in equation 3.1:

$$Y_i(t) = K_i(t)^{\alpha} H_i(t)^{\alpha} (A_i(t)L_i(t))^{1-\alpha-\beta} \tag{5.1}$$

Labor and Technology grow at rates n and g:

$$L(t) = L(0)e^{nt} \tag{5.2}$$

$$A(t) = A(0)e^{gt} \tag{5.3}$$

$A(t)L(t)$ is the number of effective units of labor and grows at rate $n + g$. We define $y \equiv Y/AL$, $k \equiv K/AL$ and $h \equiv H/AL$. The evolution of the economy is determined by the following two equations:

$$\dot{k}(t) = s^k y(t) - (n + g + \delta)k(t) \tag{5.4}$$

$$\dot{h}(t) = s^h y(t) - (n + g + \delta)h(t) \tag{5.5}$$

where s^k is the fraction of income invested in physical capital and s^h the fraction of income invested in human capital. MRW make the assumption that one unit of consumption can be transformed into one unit of human or physical capital without transaction costs. Furthermore, MRW assume the same depreciation rate δ holds for both types of capital and decreasing returns to all capital, i.e. $\alpha + \beta < 1$. This model gives a prediction for the steady state, and much of the differences in income between countries or regions is due to differences in determinants of the steady state. However, we are interested in growth rates and want to allow for the possibility that economies are out of the steady state. Therefore we use MRW's log-approximation of the speed of convergence around the steady state:

$$\frac{\partial ln(y(t))}{\partial t} = \lambda[ln(y*) - ln(y(t))], \tag{5.6}$$

with $\lambda = (n + g) + \delta)(1 - \alpha - \beta)$. Integrating this expression gives us an expression for the derivative of $ln(y(t))$ with respect to t in terms of $y(0)$. When we plug this into equation 5.6, we get the following equation:

$$ln(y(t)) = (1 - e^{-\lambda t} ln(y*) + e^{-\lambda t} ln(y(0)), \tag{5.7}$$

where $y(0)$ is GDP per effective worker at the beginning of the period under study. By subtracting $y(0)$ from both sides and substituting for the expression found for $y*$, MRW end up with the following specification:

$$ln(y(t)) - ln(y(0)) = (1 - e^{-\lambda t})\frac{\alpha}{1-\alpha-\beta} ln(s^k) + \tag{5.8}$$

$$(1 - e^{-\lambda t})\frac{\beta}{1-\alpha-\beta} ln(s^h) - \tag{5.9}$$

$$(1 - e^{-\lambda t})\frac{\alpha+\beta}{1-\alpha-\beta} ln(n+g+\delta) - (1 - e^{-\lambda t}) ln(y(0)) \tag{5.10}$$

This means that in the augmented Solow model we can estimate the parameters of the model by regressing the average growth of income on the income share of physical capital, the income share of human capital, the growth rates of population and technology, the depreciation rate and the initial level of income. Taking technical change g and depreciation δ to be the same across our European regions, we can estimate equation 3.2.

Table 7: Cross-correlation table

Variables	ΔlnY	$lnY(1991)$	s^k	s^h	n	$R\&D$	DIV	YNG	$NEIGH$	TEA	TEA_{in}	TEA_{hj}
ΔlnY	1.000											
$lnY(1991)$	-0.326*	1.000										
s^k	0.293*	-0.530*	1.000									
s^h	0.009	-0.119	-0.150	1.000								
n	0.161	0.238*	-0.167	0.213*	1.000							
$R\&D$	-0.098	0.246*	-0.295*	0.227*	-0.022	1.000						
DIV	0.136	-0.489*	0.053	0.570*	-0.007	0.163	1.000					
YNG	0.131	-0.187	0.379*	0.158	0.424*	-0.176	0.080	1.000				
$NEIGH$	0.433*	-0.373*	0.134	-0.005	-0.046	-0.153	0.027	-0.015	1.000			
TEA	0.197	-0.180	0.170	-0.077	0.161	-0.161	-0.150	0.302*	0.269*	1.000		
TEA_{in}	0.165	0.251*	-0.175	-0.056	0.193	0.233*	-0.118	-0.036	0.064	0.534*	1.000	
TEA_{hj}	0.006	0.266*	-0.156	-0.208*	0.013	0.125	-0.314*	0.019	-0.001	0.568*	0.704*	1.000