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How socio-technical regimes affect low-carbon innovation: Global pressures inhibiting industrial heat pumps in the Netherlands

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ABSTRACT

This paper shows that the socio-technical barriers that sustainable innovations face, may stem from global regimes. Existing transitions approaches like the Technological Innovation System (TIS), overlook the impact of global regimes on radical innovation. Building on institutional theory, we therefore develop a theoretical framework that captures TIS-regime interaction, allowing us to analyze the impact of globalized industries on the development and diffusion of promising radical low-carbon innovations. This is applied to a qualitative case study of how the global industrial processing regime influenced the Dutch industrial heat pump (IHP) TIS over the past 30 years. We identify several mechanisms through which the regime's coercive, normative and mimetic institutional pressures inhibit TIS development. Takeovers by multinational owners for example translated into corporate strategies focused on short-term economic valuation with no priority to sustainability. TIS actors respond to and strategically deal with these pressures. We show that the institutionalization of a new logic in the global regime can outpace the rate of technological development of the radical innovation, causing it to become less attractive over time despite technological performance increases. The impact of global regimes limits the effectiveness of national policy support for a TIS.

1. Introduction

The research on the dynamics of sustainability transitions has led to the development of several theoretical frameworks that help in understanding why radical, low-carbon innovations are slow to break through. These frameworks show the development and diffusion of a radical innovation or new technology as the outcome of coevolutionary processes within socio-technical systems comprised of actors, networks, and institutions [1]. One such framework is the technological innovation system (TIS) perspective and its structural–functional approach, which has been acclaimed for identifying the drivers and, particularly, the barriers to the development and diffusion of novel technologies. However, despite its strengths in systematically identifying the barriers to innovation, it has increasingly been criticized for underconceptualizing the geographical and sectoral contexts within which TIS emerge, which may explain the origin or root cause of the barriers to radical innovation [2–4].

Therefore, attempts have been made to reconcile the TIS perspective with concepts borrowed from other theoretical frameworks. One of the most promising is the notion of socio-technical regimes; this concept is used to describe the dominant rules of the game of an established system which restrains the development and diffusion of radical innovation [e.g., 4,5]. Over the past decade, the conceptualization of socio-technical regimes has undergone what can be called an institutional and geographical turn. On the one hand, research on the geography of transitions [7,8] has turned to focusing on where socio-technical regimes develop and where they have an impact, accounting for the highly uneven geographical dynamics of many transitions. On the other hand, regimes have been conceptualized as institutional rationalities that account for their rule-like character [9]. Taking into account both of these theoretical developments, Fuenfschilling and Binz [10] introduced the concept of the global socio-technical regime; they highlighted the multi-scalar characteristics of socio-technical regimes, showing that the globalized nature of many industries leads to globally shared “rules of the game” that can restrain radical innovation.

Although the global regime framework is a promising framework for better understanding the geographical dimensions of sustainability transitions, the framework needs further development. In particular, it is not yet specified how and through which mechanisms a global regime exerts pressure on local or national technological developments, and it is

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unclear to what extent regions or countries can deviate from these global pressures to foster radical innovation [11–13]. In the current paper, we offer a conceptual specification of the institutional pressures stemming from global regimes and their impact on TIS development. In line with previous research, we conceptualize institutional pressures as isomorphic processes that can have coercive, normative, or mimetic origins [14,15]. By studying how a TIS is affected by such isomorphic pressures, we improve the current understanding of how global regimes impact radical innovation.

We explore these dynamics by studying a particular case of radical, low-carbon innovation in the processing industry in the Netherlands: the 'industrial heat pump' (IHP). In the Netherlands, the industrial processing of materials such as chemicals and food accounts for 42% of CO_2 emissions [16]. The IHP has the potential to contribute to reducing these emissions, but despite substantial TIS developments over the past few decades, the technology is unable to break through in the Dutch and in other markets [17]. Hence, we answer the following question: "How does the global industrial processing regime impact the barriers to the development and diffusion of the IHP in the Netherlands, and how do Dutch TIS actors respond to these impacts?"

The remainder of the present paper is structured as follows: To establish a framework for how global regimes may impact radical innovation, the theory section links the TIS literature to the concept of a global regime and of isomorphic institutional pressures. The Methods section introduces the case and describes the methods used for data collection and analysis. The Results section starts with a reconstruction and description of the historical development of the global regime of the processing industry, outlining three ideal-type institutional logics and their alignment with the IHP. The same is done for the Dutch industrial processing regime so that, subsequently, the impact of the global regime on the Dutch TIS can be accessed via a complementary structural–functional analysis. We also identify various response strategies by local TIS actors. The paper then discusses the theoretical framework and offers policy implications before ending with a Conclusion section.

2. Theoretical framework

2.1. Global socio-technical regimes

The concept of the socio-technical regime was developed to understand the stability of existing socio-technical systems [18]. Regimes are typically defined as "*semi-coherent rule sets carried by different social groups [such as government, firms, intermediaries, users, research institutes, financiers, etcetera], which stabilize a technological trajectory and function as a selection and retention mechanism*" [15,p. 1260]. These rule sets result in a "*dominant rationality in a system that specifies ideas about cause and effect, defines legitimate means-end-relationships, influences what is conceivable and orders interactions of all sorts*" [8,p. 738]. Thus, regimes streamline behavior and maintain the status quo of a system by exerting a range of institutional pressures (see Section 2.3).

In the wake of the literature increasingly focusing on the geography of transition [20], scholars have started to pay attention to where these rules of the game develop and where they have an impact. Fuenfschilling and Binz [8] introduced the concept of the global socio-technical regime, here as a way to acknowledge the increasingly globalized nature of many industries and their institutional effects in specific places [21]; the authors proposed that dominant regime rationalities are diffused on a global scale because they are enacted and maintained by globally active organizations and movements that wield military, economic, political, or cultural power [8]. The authors combined insights from organizational institutionalism, especially world polity studies and writings on institutional isomorphism [15,22], with the global production network and global value chain perspectives [23–26], to explain the multi-scalar dynamics of regimes.

A global regime is consequently defined as "*the dominant institutional rationality in a socio-technical system, which depicts a structural pattern between actors, institutions, and technologies that has reached validity beyond specific territorial contexts, and which is diffused through internationalized networks*" [8,p. 738]. Institutional rationality is operationalized using the concept of institutional logics [27,28], which are commonly understood as "*organizing principles that govern the selection of technologies, define what kinds of actors are authorized to make claims, shape, and constrain the behavioral possibilities of actors, and specify criteria of effectiveness and efficiency*" [24,p. 328].

The research on institutional logics is particularly prevalent in the field of organizational institutionalism, and it has been shown to be fruitful when it comes to understanding actor strategies, the diffusion of practices within and across fields, and the development of industries more generally [28,30]. More recently, the perspective has also been leveraged to explain innovation dynamics in a variety of sectors, among others, ICT, pharmaceuticals, and energy [31–33]. In general, it has been suggested that Western societies typically consist of a few dominant institutions that each come with their own very ideal-typical institutional logics, that is, a particular rationality of how to make sense of the world and how to legitimately operate in it. Scholars have identified seven main societal institutions: the family, community, religion, professions, state, corporation, and market [25; see Appendix I for an overview]. It is assumed that each socio-technical system (or any meso-level unit of analysis, e.g., industry, field, TIS, country) will be shaped in some form by one or more of those institutional societal sector logics, thus developing a unique institutional logic of its own that guides cognition and behavior [28].

In the current paper, we follow Fuenfschilling [35] in arguing that the influence of each logic depends on the degree of its institutionalization. The more a logic is institutionalized—that is, the more it has materialized into concrete practices—the more it will shape the cognition and behavior of actors. Depending on how well the different logics are aligned in a system and how coherent they are, different dynamics unfold [35]. Studies in the realm of organizational institutionalism have investigated such dynamics under the header of institutional complexity [36,37]. These studies have shown that the degree of elaboration and coherence of different institutional logics in a field greatly affects organizational structures and strategies. Of particular importance for the purpose of the current paper is the dynamic between dominant institutional logics in a regime versus in an emerging TIS. We assume that the more aligned the overarching institutional logics of the new TIS and the established regime are, the easier it will be for an innovation to diffuse and institutionalize. On the other hand, the more conflicts between the two, the more challenging it will be for the TIS to gain ground. Assuming that more radical innovations tend to function under a distinctive logic than the established system, we expect to find tensions between the institutional logics of the global regime and those of the emerging TIS that result in barriers to TIS development.

To the best of our knowledge, only a limited number of studies have investigated multi-scalar regime dynamics. Although Fuenfschilling and Binz [8] applied the concept of the global regime to a case in the water sector, showing how the global regime heavily shaped the development of the Chinese water sector, Bauer and Fuenfschilling [38] studied how the global regime in the petrochemical sector hampered the development of sustainability initiatives in the Swedish chemical sector. Both cases, however, lacked a thorough conceptualization of the specific institutional pressures exerted by the regime and of the local context that is affected by these pressures. There is no clear evidence on how a global regime affects innovation activities and how the actors react to pressures from global industries. In the next sections, we introduce the concept of the TIS, outlining through what type of institutional pressures a global regime can influence the development of radical innovations.

2.2. Technological innovation systems

The TIS framework has provided valuable insights into how to stimulate the development and diffusion of emerging technologies. A

TIS is defined as "*a dynamic network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion, and utilization of technology*" [29,p. 93] [39]. Notably, the structural–functional approach has proven to be an adequate "focusing device" for identifying the weaknesses or systemic barriers in a TIS [40]; it identifies seven system functions—or innovation processes—that are key to the development and diffusion of any new technology (see Table 2.1 for an overview). These system functions are assessed to "focus" the analysis on identifying underlying systemic barriers.

The TIS approach has been criticized, however, for under-conceptualizing contextual structures [2,3]. Notably, the TIS has been perceived by some as inward oriented and paying insufficient attention to the underlying nature of systemic barriers that emerge from the system's environment [5]. Although recent contributions have created a deeper understanding of the underlying causes of systemic barriers, of their interrelatedness, and how this can amount to systemic lock-in [2,4,42], the TIS still misses an understanding of *why and* via *which mechanisms* incumbent systems inhibit TIS development.

At the same time, a TIS tends to overlook geographical contexts because of its history of methodological nationalism [7,8,43–46]. However, even with a national focus, TIS studies must better understand the innovation processes that take place at the global level. TISs do not have to be developed 'fully' within one nation. Instead, international linkages between TIS structures become crucially important with innovation growing into an increasingly global phenomenon [7,43].

We suggest that to overcome both of these contextual weaknesses, TIS can be fruitfully studied in the context of *global regimes*. This combination allows us to study the global context in which the TIS actors compete with incumbent systems for resources, market share, legitimacy, or engage in other innovation processes. In the next section, we outline the institutional pressures through which a global regime may impact TIS developments.

2.3. The impacts of global regimes on the TIS of radical innovation

The development of radical innovation is considered crucial for any kind of sustainability transition [46,47]. To better understand the impacts of global industrial structures on radical innovation, we take a closer look at how global regimes affect TIS development. Places with cultural, institutional, and material preconditions that deviate from those of the global regime are assumed to be breeding grounds for new institutional logics because they have the potential to establish new, more sustainable socio-technical configurations (i.e., niches) [48]. It is here that TISs around alternative technologies may emerge [5]. However, the institutionalization of a TIS occurs in close interaction with existing structures, that is, with the regime. As a TIS develops into a more stable configuration, the often striking mismatch between the TIS and regime logics becomes increasingly apparent [49]. Consequently, TIS development is expected to experience increasingly substantial barriers, mainly because of the hampering institutional pressures exerted by global regimes.

Table 2.1
Overview of system functions, based on Hekkert et al. [41].

System function and acronym used in Results section	Description
Entrepreneurial activities (F1)	Entrepreneurial experimentation and commercialization of innovations (e.g., pilots)
Knowledge development (F2)	Learning by searching and by doing, e.g., R&D
Knowledge diffusion (F3)	Exchange of tacit and codified knowledge in networks, including learning by interacting and by using
Guidance of the search (F4)	Providing directionality toward the focal technology and its different technological designs, e.g., through positive expectations
Market formation (F5)	Creating demand for the technology, notably through protected spaces, e.g., induced by regulations, policy, and standards
Resources mobilization (F6)	Allocating financial, human, and physical resources to fulfill other system functions
Creation of legitimacy (F7)	Create stakeholder support for the technology, e.g., through lobby

Following institutional theory, we posit that global regimes maintain their rationality through three particular isomorphic institutional pressures: coercive, normative, and mimetic [14,15]. Below, we illustrate how these pressures, as exerted by the global regime, may impact radical innovation by the TIS.

Coercive pressures are generally assumed to stem from regulative institutions, such as laws and regulations, or from direct hierarchical power relations. Typical examples are government policies that favor regime practices, such as regulatory standards, antitrust laws, and protectionist policies, but corporate coercive pressures are also pervasive. Various studies have, for example, shown that corporate conglomerate headquarters enforce subsidiaries to adopt certain investment strategies and subject them to performance evaluations [14,50]. The literature on institutional ownership has indicated that the same applies to powerful shareholders [51,52]. Mutual funds and investment banks, as opposed to pension funds and state investors, often pressure firms to focus on short-term economic valuations, cutting expenses in innovation and corporate social responsibility as a result [51,52]. Firms with a powerful position in the global value chain can also exert coercive pressures to upstream and downstream organizations to not buy from or supply new entrants introducing (the TIS's) radical innovation [51–53]. Finally, large, multinational companies can exert coercive and normative pressure on governments against regime-destabilizing policies, particularly when they form a closed industry front [54–57].

Normative pressures are mostly associated with the best practices and professional standards that are diffused through education or membership in professional associations. These pressures are often connected to some form of inclusion in an epistemic and professional community [14,15]. For example, managers that share educational backgrounds (which is often an important selection criterion for higher management positions) or other communities tend to view problems and solutions in similar ways [14,15]. This manifests in their management strategies, which reflect the dominant regime logic as opposed to that of the TIS. Finally, voluntary industry standards have been shown to effectively maintain the status quo, such as with new products like LED lamps [58] and alternative construction materials [4], may be incompatible with such standards—withholding them market access.

Mimetic pressures result in imitation in situations of uncertainty, where seemingly successful actors and opinion leaders are copied as a strategy of legitimation and risk aversion [14,59]. Sustainability brings about such uncertainty and causes firms to mimic successful actors, which are typically those regime actors that exploit the low-hanging fruits of incremental innovation [60]. Fuenfschilling and Binz [8,p. 738] argued that (TIS) actors in the periphery of the global regime that aim to benefit from global knowledge, resources, and markets often need to adapt to the needs of the powerful global firms that dominate these global value chains. This means that the radicality of the TIS's innovations may be lost because TIS actors are pressured to "fit and conform" their innovations to the global regime's selection environment [61,62]. Multinational consultancies are also a strong force of mimetic pressure because they tend to recommend similar organizational models and technological solutions to their customers; the demand for their services is highest during times of uncertainty [10,14]. Because these customers can be policy makers (e.g., for consultation on what technologies to support) and firms along the global value chain (e.g., technology purchase consultation, market consultations on prospected technology development, or strategic consultation), this could have a profound effect on different parts of the emerging TIS.

Thus, the global regime's three isomorphic pressures often result in the maintenance of the status quo, that is, in the reproduction of the regime and its diffusion across space, which is expected to pressure the TIS in various ways. Table 2.2 provides an overview of the institutional pressures and expected impacts on the TIS. The aim of the current paper is to empirically explore to what extent we can retrace these different pressures and the barriers they pose to TIS expansion, including analyzing the responses of TIS actors to those pressures. These dynamics are captured in our conceptual framework in Fig. 2.1, which depicts how global regime logics exert isomorphic pressures on local TIS and how these pressures translate into systemic barriers when the TIS logics do not match global regime logics.

Table 2.2
Overview of global regime's isomorphic pressures on TIS.

Isomorphic global regime pressure	Expected impact on TIS
Coercive pressure	Through *direct authority*, conglomerates are expected to enforce management decisions on subsidiaries that impair TIS technology development and adoption, as do shareholders, who enforce such decisions on corporate management. Through *buyer or supplier power*, global regime actors are expected to block access to the global value chain to TIS actors. Global regulative power for radical clean innovation may be hindered by coordination issues and the *powerful lobby* of the global industry.
Normative pressure	*Dominant educational logics*, which may not be in line with the TIS logic, are reflected in a corporate and public management. *Voluntary standards* may inhibit radical innovations.
Mimetic pressure	Radical innovations are pressured to *fit and conform* to the regime's selection environment. Multinational *consultancies reproduce* the regime's corporate and public management logics, which may not be in line with that of the TIS.

3. Methods

Our empirical analysis centers on a qualitative, explorative case study of an innovation with the potential to improve energy efficiency across a variety of industrial processes: the IHP. The present study entails analysis of the historical development of the global regime of the process industry, that is, the sector where the IHP could potentially bring substantial sustainability gains. Furthermore, it entails analysis of the IHP-TIS, here with a specific focus on the Netherlands. We then reconstruct the institutional pressures from the regime onto the TIS and portray some responses to these pressures. The methodological considerations are outlined below.

3.1. Case description: the industrial heat pump

A heat pump literally “pumps heat” from a lower-temperature heat source to a higher-temperature heat sink, whereby a working fluid is used as the medium [63]. In industry, the heat source is generally waste heat from an industrial process, whereas the heat sink is a higher-temperature input heat stream for another, or the same, industrial process. In this way, waste heat can be “upgraded” to useful heat, thus significantly contributing to reducing industrial CO_2 emissions. In Europe alone, 3803 potential locations for IHPs have been identified, representing a total potential of up to 22% of heat demand under 200 °C in the chemical, refinery, paper, and food industries [64]. The most common IHP, which is currently at the beginning of the take-off phase, is the so-called compression heat pump for heat sink temperatures of up to 110 °C [63]; it is currently applied in niche areas, especially in the food industry [63]. Compression heat pumps using alternative working fluids to achieve heat sink temperatures up to 180 °C are still in the pilot phase, whereas alternative versions, such as the chemical heat pump and thermo-acoustic heat pump, are in the earlier phases of development [65]. These alternative heat pumps have the potential to reach temperatures of up to 250 °C, thereby coming into the range of lower-temperature chemical processes [66,67].

The IHP is produced by specialized technology suppliers providing (energy-efficient) solutions to industrial companies. In the Netherlands, heat pumps are manufactured by a handful of smaller-scale, specialized technology providers. These specialized suppliers strive to sell their solutions to large companies organized in industrial clusters that operate in global markets. Dutch knowledge institutes and heat pump providers work closely together in research and development, providing tailor-made solutions that deviate from the global regime's focus on standardized solutions. These Dutch technology suppliers are among the world leaders in heat pump technology [64]. However, despite all these activities and the great potential of the technology to achieve sustainability gains, the diffusion of heat pumps across energy-intensive processing industries has been difficult [17,68]. We expect this because of the global industrial processing regime pressuring industrial companies in the Netherlands and beyond to follow institutional logics that do not fit the IHP, resulting in barriers to IHP-TIS development. This makes the case well suited to illustrate our conceptual approach.

3.2. Research design and analytical approach

The current qualitative case study takes a two-pronged approach toward uncovering the impact of a global regime on radical innovation. The first part of our analysis focuses on the identification of institutional logics in the global regime over time. The second part reconstructs the TIS of the heat pump, identifying institutional pressures from the regime, as well as responses from TIS actors.

3.2.1. Data collection

Our data comprise a wide range of qualitative sources (see Table 3.1 for an overview), including 34 interviews with IHP suppliers (6), industrial companies (9), general technology suppliers (8), consultants (3), engineering firms (3), research institutes (2), an industrial utilities provider, an industry association, and one interview with two government officials. These interviews, which were carried out in a face-to-face format, used semistructured sets of interview questions that revolved around understanding the actor's view of the TIS and the broader regime rules. Specifically, we were interested in understanding the barriers to TIS development, their underlying causes, and how these causes relate to the global regime. The interviews were transcribed and supplemented with public reports on IHPs, policy documents on current and past policies, and notes made during meetings with industrial professionals (e.g., conferences and workshops). These data sources were bundled in a digital database and subsequently coded and analyzed using NVivo.

3.2.2. Data analysis

Our analytical approach, which is further detailed below, has been structured using the following steps:

1. Identifying institutional logics via pattern matching:
   a. Identify ideal-type logics that characterize the global regime
   b. Study their fit with IHP-TIS
   c. Study their impact on the NL
2. Mapping the TIS and regime pressures:
   a. Structural–functional approach to mapping IHP-TIS and barriers
   b. Coding contextual factors as isomorphic pressures
   c. Coding response strategies by TIS actors
3. Matching TIS barriers and regime pressures

The first step of analysis entailed identifying institutional logics in the process industry over time. For this purpose, we used the “pattern-matching” technique [69]. The pattern-matching technique is founded on the idea that the social world is infinitely complex and that it cannot be understood when this complexity is maintained during the research

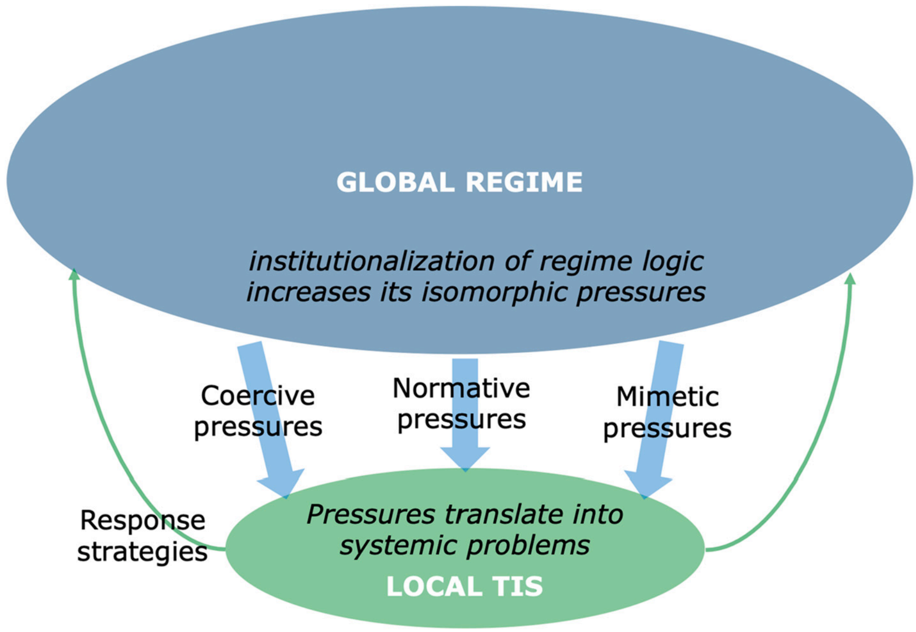

Fig. 2.1. Conceptual framework: How global regime pressures impact local TIS.

Table 3.1
Overview of data sources.

Data sources	Amount	Corresponding amount of coded textual fragments
Interviews	34 interviews with 39 individuals	1074
Factsheets and popular articles	38	235
Presentations, meeting and workshop notes	48	617
Documents of government programs and regulations	31	230
Reports (e.g., consultancy and research project reports)	80	444
Websites and news articles	191	439
Total amount of coded textual fragments:		3039

process. Instead, understanding this process requires deliberate simplification so that patterns become visible [70]. Pattern matching starts with the formulation of ideal-type logics. Although ideal types are analytical constructs—and thereby do not exist in their purity in reality—they are inspired by and founded upon empirical work [71]. For the present paper, three ideal-type logics were formulated based on historical analysis of the global processing industry. This was done using the conventional coding categories for identifying institutional logics developed by Fuenfschilling and Truffer [9] and building on Thornton and Ocasio [28], including values, mission, expertise, basis of strategy, technologies, efficiency focus, view on business, sources of authority, and informal control mechanisms. The formulated ideal-type logics are presented in Section 4.1, including their historical dominance at the global level (Section 4.1.1), the extent of fit between the IHP and the formulated ideal-type logics (Section 4.1.2), and the institutionalization of these ideal-type logics in the Netherlands (Section 4.2.1). Appendix II provides exemplary quotes that reflect the empirical foundations of these ideal types. Appendix III lists the practices, regulations, policies, and noteworthy historical happenings that provide the indicators for the degree of institutionalization of logics in the Netherlands.

The second part of our analysis focused on identifying institutional pressures from the global regime onto the Dutch IHP-TIS (presented in Section 4.2.2). To achieve this purpose, we performed structural–functional TIS analysis to identify systemic barriers and study their interrelations [see 31,32]. Our analysis is based on open coding [72] of textual fragments. Here, coded fragments were first allocated to the respective system functions and later grouped into categories according to the guidelines on focused coding [73]. Data collection continued until new data no longer led to changes in categories, that is, until theoretical saturation has been achieved. Categories related to international context were subsequently classified per type of isomorphic pressure (i.e., mimetic, normative, or coercive) they emanated on the Dutch context. Responses by Dutch actors to these isomorphic pressures were first open coded and then aggregated using focused coding before classifying them as exerting mimetic, normative, or coercive pressures, if any (Section 4.4).

Finally, we linked the systemic barriers identified in the Dutch context to the types of isomorphic pressures emanating from the global regime (Section 4.3). This was based on what the interviewees had explained about "what caused what." In some cases, cause-and-effect relations could be logically distilled by combining sources. For instance, some data show how a global regime logic drove fragmentation of Dutch vertically integrated industrial clusters into horizontally focused separate entities, whereas other data explained how this fragmentation inhibits IHP implementation by causing various coordination problems. Only systemic barriers that were found to be directly or indirectly the result of the global regime's isomorphic pressures were included in the Results section.

4. Results

4.1. *The global regime of the process industry*

In Section 4.1.1, we present our historical reconstruction of different ideal-type institutional logics in the processing industry and their relative importance over time, going back as far as the nineteenth century, during which large industrial conglomerates and industrial capitalism emerged [74]. Section 4.1.2 then describes the fit of these ideal-type logics with the socio-technical characteristics of the IHP.

4.1.1. *Ideal-type logics in the global process industry*

The process industry was built on professional, corporation, and state institutional sector logics. Scientific and technical ingenuity have been highly valued in society since the Age of Enlightenment, which led to numerous scientific and technical breakthroughs. Because of the close ties between industry and universities at the time of the Industrial Revolution, the striving for a personal reputation that characterizes the scientific field was also felt in the emergent process industry. For instance, not only were newly developed chemical processes and techniques named after their inventors, but also many industrial companies were as well.[1] The main basis of the strategy was to profit from these breakthroughs. Through the combined influence of the corporation and state sector logics, both privately owned and state-owned companies started up. Within these companies, the main mission was to develop new chemical processes, materials, and technologies based on scientific and technical expertise. These companies emerged around places of abundant natural resources necessary for industrial processes, thus creating clusters of industrial activity. The board of directors and top management, consisting of both scientists and engineers, provided the source of authority in private companies, while the state naturally provided the source of authority in state-owned enterprises. This ideal-type "*engineering logic*," which is anchored in the institutional sector logics of the profession, corporation, and state, became dominant internationally (see Table 4.1. Appendix II for lists of quotes from various sources that reflect the empirical foundation of this logic).

Because scientific and technical breakthroughs came from Europe during the Industrial Revolution and later from the US, it was no surprise that European and US companies first dominated the international market. After a period of consolidation, a handful of giant industrial companies came to dominate the market in the early nineteenth century, exporting their products all over the world. After the Second World War, while European companies were recovering, the US took over as a leading industrial innovator.[2] As international markets opened, investment capital more easily circulated among countries. This led the industrial giants to establish international production units, thereby becoming truly multinational companies. When these multinationals continued diversifying into new markets that opened up to them through their inventions, they turned into international conglomerates.

Table 4.1
Ideal-type logics in the industrial sector.

Categories	Engineering logic	Sustainability logic	Capitalist logic
Sector logic	Profession, corporation, state	State, community, corporation	Market, corporation
Values	Scientific ingenuity	Environmental sustainability	Economic performance
Mission	Developing new materials, processes, and technologies	Cost effective CO_2 reduction	Profit
Expertise	Scientific, technical	Technical, Economic	Economic
Basis of strategy	Increase market share, personal reputation	Reduce CO_2 emissions and increase profit	Increase profit margin
Technologies	Innovative technology	Cost-effective CO_2 reduction technologies	Cost-effective technology
Efficiency focus	Technical efficiency	CO_2 efficiency	Economic efficiency
View on business	Long term	Long term	Short term
Sources of authority	Board of directors, state	Board of directors, state regulations	Shareholders, board of directors
Informal control mechanisms	Professional standards	Community	Financial analysts

Over the course of several decades after the Second World War, a shift took place in the direction of the market logic, here at the expense of state and profession logics. The opening of international markets substantially increased competition in a new "level playing field," while conglomerate expansion had led to overcapacity in commodity markets. Global competition was further exacerbated by Asian and Middle Eastern companies entering the global bulk commodity markets, which required technologically less-advanced industrial processes. Now that a technological lead no longer guaranteed economic performance, remaining profitable in the competitive global market became a mission in and of itself.

Increasing profit margin[3] became the leading strategy of Western processing companies. This was achieved not only by decreasing costs and divestment of less profitable activities (e.g., commodities), but also by pursuing activities in areas with potentially higher margins (e.g., fine or specialty chemicals)—as was often done through acquisitions. Companies focused their attention on core activities and selling less profitable divisions to other companies, private equity firms, or entrepreneurs. Buyers were herein facilitated by newly developed corporate financing strategies, such as the leveraged buyout model. Hence, looking to increase profit margins, the new norm became to reduce costs and risks on the production side while taking risks on the commercial side (acquisitions).

Maintenance and utilities activities were also often considered non-core and divested, making industrial companies more dependent on suppliers for new technologies and innovations. Because industrial companies prefer standardized, low-cost solutions, those technology suppliers that offer such solutions become successful. This turned Western conglomerates into highly specialized companies that lack in-house innovation capacity and that instead compete through market size in a narrow value chain segment.

The sources of authority also shifted. As economic expertise became more important, technicians in management had been replaced by economists who were trained in economic theory and had an affinity with financial indicators. This coincided with an upsurge in both privately and state-owned enterprises becoming listed on stock markets, making shareholders the main source of authority. Financial analysts, who focus on short-term indicators like quarterly profits, liquidity, and solvability, now began to form a new informal control mechanism. The fact that companies had a stock market listing also opened new possibilities for activist shareholders to influence or circumvent boards of directors. Private equity companies could, for instance, now pressure industrial companies to increase profit margins by further decreasing costs or intensifying divestments. Also, raiders acquired industrial companies with the help of big capital. First in the US and later also in Europe, many conglomerate industrial companies were acquired, split up, and sold in pieces for a profit by these new sources of authority.

The above developments and illustrative quotes in Appendix II reflect the ideal-type *capitalist logic* (originating from the market/corporation sector logics), replacing the engineering logic as the dominant logic in the global industry.

Finally, a third ideal-type logic addressing environmental sustainability concerns is currently developing at the periphery of the sector. Sustainability logic can be interpreted as having its roots in the institutional logics of the community and corporation. A starting point can be identified in 1984 with the Indian Bhopal disaster, which proved that community safety had not been a priority within the global process industry. It was a wake-up call for national governments and industrial companies worldwide, leading to improved plant safety around the

[1] Among others, Koch, Nobel, Solvay, Bayer, Eastman, DuPont, Dow, Bosch, Pfizer, and Linde (*Leblanc process for sodium carbonate production, Schloesing and Rolland process, Solvay gas-liquid counterflow mixing pipe, Haber-Bosch process*).

[2] In part because of German patents being confiscated by the Allied forces.

[3] "The market is thus dominated by price competition and firms engage in cost leadership strategies which guide their innovation initiatives" [30,p. 7].

world.

Although climate change as a community concern has been advocated for by scientists since the 1970s, the EU CO_2 trading scheme (EU ETS) initiated in 2005 marked the first time industry was directly affected by a regulation in this area. However, a powerful industrial lobby argued that regulation drives up prices and forces industry to relocate elsewhere because of cutthroat global competition (carbon leakage). Lobby activities have been targeted at maintaining an international level playing field, and as a result, industrial buyers have largely been protected from climate regulation. For instance, the Kyoto Protocol did not translate into sanctionable goals or regulations; instead, voluntary agreements were the default policy instrument in nations worldwide. Although the EU ETS has increased in its stringency, it still largely protects basic processing industries to maintain their economic activities within Europe, for instance through free CO_2 emission rights for most production volume and through financial compensation for "administrative burden." With the 2015 Paris Agreement, however, member states worldwide committed themselves to the creation of national climate action plans that will affect industrial companies worldwide, thereby potentially strengthening the influence of the sustainability logic.[4]

Because the process industry is dominated by companies, its main mission is to achieve CO_2 reductions in a cost-effective way. This necessitates not only a combination of both technical and economic expertise, but also a focus on CO_2-efficient and cost-effective technologies. This requires risk-taking in operations, which conflicts with the dominant capitalist logic. Although the board of directors remains the main source of authority, the community functions as an informal control mechanism that supports a sustainability logic (see Appendix II for illustrative quotes).

4.1.2. Fit of industrial heat pumps with global regime logics

The IHP is a poster-child technology for *engineering logic* for various reasons. First, it can reach technical efficiencies of multiple hundred percent, aligning with the logic's efficiency focus. Second, tailor-made designs to fit the heat pump to local conditions and its integration into industrial processes require technical expertise and ingenuity, as well as risk-taking in operations. Third, the IHP is generally seen as being part of utilities (the production of heat and electricity required for the industrial process), and an IHP may connect industrial processes. Larger conglomerate industrial companies that operate numerous such industrial processes in an industrial cluster have their utilities in house, which typical of the engineering logic, and they generally have the most to gain from IHPs.

The CO_2 efficiency of the IHP aligns with the *sustainability logic*. To reduce CO_2, the IHP is in competition with a multitude of technologies, including alternative industrial processes, carbon capture and storage, electric boilers, and district heating networks, of which the latter three do not require adaptations to the core industrial processes. However, because risk-taking in operations is considered acceptable under a sustainability logic, both standardized and tailor-made IHPs remain competitive only within certain niches. Although the IHP is no longer poster-child technology, it does have the potential to thrive when the sustainability logic becomes institutionalized.

Under the *capitalist logic*, the implementation of an innovative technology only adds value when the short-term economic performance of the company is increased, for instance, by reducing costs. Among others, financial analysts and activist shareholders will pressure boards of directors to keep investment budgets low and focus on technologies that are cost-effective in the short term. Capitalist management prefers standardized technical solutions that do not touch core industrial processes (because of a risk reduction in operations). Because the IHP does not meet these demands, it does not fit the dominant capitalist logic well.

In the next section, we elaborate on the main dynamics through which the capitalist logic is institutionalized in the Netherlands and how this has hampered IHP diffusion. First, however, we discuss the historical institutionalization of the engineering, sustainability, and capitalist logics in the Netherlands.

4.2. The process industry in the Netherlands

4.2.1. Institutionalization of ideal-type logics in the Netherlands

The Dutch process industry emerged at a time when the *engineering logic* was dominant, of which the history of the still prominent industrial companies DSM and AkzoNobel are exemplary. The Dutch government started the State Mines Company (DSM) in 1902 to delve coal. It grew into a large R&D-focused, state-owned multinational conglomerate that moved from low-end bulk products to high-end end products like specialty chemicals. AkzoNobel was formed in 1984 with the merger of Akzo, which itself was created after a series of mergers between (formerly state owned) industrial companies and Nobel industries—formed by Alfred Nobel, the inventor of dynamite. When Akzo and Nobel merged, it grew into a leading conglomerate producer of a wide range of high-end products, including innovative paints, adhesives, and specialty chemicals. The authoritative role of the state and board of directors and focus from bulk to a broad range of high-end products enabled through technical ingenuity and close ties between technical and scientific expertise are all illustrative of a dominant engineering logic.

The privatization of DSM between 1989 and 1996 signaled the increasing dominance of *capitalist logic*. A few years later, because of strong global competition in bulk chemicals, DSM also divested out of bulk chemicals to focus on the new core areas of nutrition and performance materials. Similarly, since the 1970s, increasing global competition in bulk fibers has driven Akzo to focus specifically on paints and specialty chemicals. Through strategic mergers and acquisitions, both AkzoNobel and DSM remained successful as R&D-focused industrial companies in a few highly specialized market segments. Elements of the sustainability logic are present because both companies had midterm CO_2 reduction targets and DSM based its salary bonuses equally on financial and environmental sustainability indicators. In this way, their strategies combine elements of all three ideal-type logics, reflecting the semi-coherence of the Dutch process industry regime.

The *sustainability logic* has become increasingly central in the Netherlands. Since 1992, the Dutch government has made multiyear agreements with the process industry to aim for reductions in energy use by increasing energy efficiency. However, the main aim was to increase the international competitiveness of Dutch industrial companies. Since the 2005 EU ETS, covenants were signed to reduce energy use, and energy efficiency measures with a payback time under five years became obligatory, although hardly enforced. The Dutch Energy Agreement was signed in 2013 in answer to the 2012 European goals to reduce energy use by 20% by 2020. Since 2010, the Dutch government has supported these goals via large R&D subsidies for technological innovation. These subsidies have helped Dutch technology suppliers and research institutes become leaders in tailor-made energy efficiency innovations, including the IHP. CO_2 reduction was also achieved during this period but as an indirect result of the striving for improved international competitiveness of the Dutch industry.

Since the 2015 Paris Agreement, CO_2 reduction became a main goal, and in its pursuit, in 2018, Dutch actors have started negotiating a climate agreement with the goal of reducing 49% CO_2 by 2030. The industry mostly lobbied for maintaining an international level playing field in which CO_2 reduction targets were supported by substantial subsidy schemes, although some asked for a strong climate law. The government decided on a national CO_2 tax that acts as a floor on the EU ETS price. COVID-19 has, however, postponed implementation of this

[4] The United States decided to withdraw from the Paris Agreement in 2019, and the Madrid Convention led to a "minimal" agreement.

policy by four years. All innovation policies and subsidies are aligned with CO_2 reduction as the main goal. The IHP particularly benefits from a large-scale subsidy program that benefits CO_2 reduction measures with payback times of over five years. Table 4.2 provides an overview of indicators for the institutionalization of these three logics and the resulting semi-coherence of the Dutch processing industry's regime.

4.2.2. Fit of industrial heat pump TIS with Dutch regime

The IHP benefited substantially from the Dutch policies aimed at supporting energy efficiency (F4: guidance of the search), and the focus on CO_2 emission reduction created competition for the IHP from other technologies, thereby slightly undermining its legitimacy (Function 7: creation of legitimacy). Subsidies (SF6: mobilization of resources) support IHP development from pilot project (F2: knowledge development) to demonstration (F1: entrepreneurial activities), and market implementation (F5: market formation).[5] These technological advances aim to reduce costs and increase temperature lifts, increasing the range of industrial process applications. The payback time for lower-temperature processes is already around five years, and companies with such processes are thereby obligated by law to implement them; this law is increasingly being enforced (F5: market formation). Government organizations, sector organizations, consultants, and research institutes frequently organize meetings and symposia and address questions from industrial companies, often for free (F3: knowledge diffusion). Hence, all seven system functions were supported by the policy.

Only a handful of Dutch organizations are active in IHP R&D projects or implementation. Organizations involved on the supply side are Dutch research institutes (e.g., ECN) and Dutch tailor-made technology suppliers, and on the demand side, there are the remaining Dutch-owned companies that have a strong footing in the engineering logic. As the following section will show, the main barriers to IHP implementation come from the increasing institutionalization of the capitalist logic on the demand-side companies of the innovation system.

Table 4.2
Indicators for the institutionalization of ideal-type logics in the Netherlands.

Engineering logic	Sustainability logic	Capitalist logic
• Dutch industrial companies still compete on science-based innovations • Technology suppliers and research institutes are leaders in tailor-made innovations	• CO_2 reduction as main goal in Climate Agreement • Potential CO_2 reduction as criterium in subsidy schemes • Industrial companies sending letters to government asking for stringent environmental policies • Energy efficiency measures with payback time under five years are obligatory • Increase in law enforcement • National CO_2 tax • Separate budgets for sustainability and energy efficiency measures • Bonuses of boards of directors depend on achieving both financial and environmental targets	• Foreign activist shareholders • Attention for a "level playing field" in Climate Agreement • Split of AkzoNobel • Selling of noncore activities by AkzoNobel and DSM • Lobby for "level playing field" during Climate Agreement negotiations • Focus on achieving economic growth • Sustainability programs are no longer updated after being taken over by international companies • Discontinuation of internal discussion networks/platforms that discuss energy efficiency • Little room for investments in industrial companies

4.3. The impact of the global regime on the Dutch TIS

The capitalist logic became increasingly institutionalized in the Netherlands because of institutional pressures emanating from the global regime. In this section, we present three illustrative examples of these pressures. We show how they have led to barriers within the IHP-TIS and discuss Dutch actors' responses. Appendix III provides an overview of exemplary quotes for these barriers to reflect on their empirical foundations.

4.3.1. Normative and mimetic pressures on Dutch firms

Various normative and mimetic pressures drove Dutch companies searching for economic efficiency to become highly specialized and compete on market size in narrow market segments. First, increasing global competition drove the Dutch conglomerates DSM and AkzoNobel to divest their bulk chemical divisions and refocus on high-margin core areas. Second, business schools emanated normative and mimetic pressures by teaching the strategy of focusing on core activities and increasing market size by international mergers and acquisitions, turning both DSM and AkzoNobel into highly specialized, global companies. These schools used examples from successful (especially US) companies that had made such transitions before. Large consultancy firms like McKinsey also played a role in dispersing this strategy of focusing on core activities across the globe.

The pursuit of this strategy separated previously integrated value chains in Dutch industrial clusters and the separation of utilities from industrial companies. For instance, until 2002, all factories and research activities of the Chemelot industrial cluster were owned by DSM alone; today, this cluster comprises more than 150 companies. The Utility Support Group (USG), a former division of DSM, now produces utilities (e.g., heat, electricity, nitrogen, air, water) for numerous companies in the industrial cluster. This shift in the direction of the capitalist logic has led Dutch industrial clusters to become strongly fragmented.

For an IHP, the fragmented nature of industrial clusters creates important barriers. First, an IHP often connects industrial processes, and these are now often owned by different companies, resulting in coordination problems for new IHP projects (F3). The IHP also affects maintenance and utilities, both of which are now generally outsourced via long-term contracts with set energy demands. These contracts prevent the monetization of the IHP's financial benefits because lowered heat demands do not lead to reduced costs (F6). In most industrial parks, activities are organized to discuss energy efficiency, thus providing opportunities to overcome the coordination barrier that impairs IHP diffusion. However, the active involvement of companies within such initiatives remains low (F3) because of other types of pressures coming forth from the international dominance of the capitalist logic, to which we turn next.

4.3.2. Coercive pressures after takeovers by multinational owners

The noncore divisions sold off by Dutch process companies gained new owners, often multinational companies active in global markets, and these companies coerce their Dutch subsidiaries to follow strategies that are in line with the globally dominant capitalist logic. These Dutch subsidiaries constitute an important market segment for the potential buyers of IHPs. Dutch subsidiaries are, for instance, instructed to further intensify the selling of noncore activities, thereby enlarging the earlier mentioned barriers related to the fragmented industrial clusters. Foreign management may also coerce a "lean" company strategy—sometimes

[5] Pilot projects are mainly subsidized through the Joint Industry Projects (JIP) measure and the Demonstratie Energie- en Klimaatinnovatie (DEI+). The DEI+ also subsidizes demonstration projects. Market implementation is subsidized with the SDE++ measure, which closes the gap between the payback time of CO_2 reduction measures and the five year payback time requirement.

part of a "buy-squeeze-repeat" strategy,[6] whereby all activities not necessary for the core processes are given up.

In addition, when a Dutch company or division is taken over, it often becomes necessary to gain permission for investment decisions from the international headquarters (F4). When the new owner follows a capitalist logic, which is often the case, strict return on investment and payback-time criteria are dictated that the IHP does not yet satisfy (F4). Budgets are also often reduced (F6), leading investments to be spent on process-related investments that satisfy these strict investment criteria (F5). It is not uncommon for only investments with a payback time below two years to be funded, even though energy efficiency projects with a payback time of less than five years are obligatory by Dutch law (F4/F6). Since the new SDE++ implementation subsidy only reimburses costs above the five-year payback time, it remains questionable whether Dutch subsidiaries will gain permission from their multinational owners to initiate energy efficiency projects.

Finally, global competition pressures have already inhibited industrial companies from taking risks in their core processes, but this is exacerbated after a takeover. Because the IHP is an innovative technology that touches their core production process, industrial companies easily perceive it as too risky (F4). This not only decreases demand for technologies that touch the core process further (F5), but also makes it even harder to find locations for research and demonstration projects (F1/F2).

Hence, the lean strategy imposed by a multinational owner stops R&D activities and external collaborations (F1) while discontinuing collaboration networks on energy efficiency (F3). In general, the focus on core activities and "lean" strategies means there is little interest in project evaluation or sharing of project results (F3), and companies do not attend discussions of more radical sustainable innovations like the IHP (F3). Lean process companies no longer have the knowledge in house to implement IHPs, and they are often not familiar with these capabilities of technology suppliers (F3). In turn, technology suppliers do not know who in the process company should be approached when it comes to selling their IHP (F5). This leads to a low demand for IHP (F5).

Because the sustainability logic has remained in the periphery at the global level, environmental sustainability generally moves down in priority after a takeover (F4). For instance, looking back at their origin, Dutch industrial companies used to adhere to the regulatory demand of making energy efficiency investments with a payback time under five years. However, risk managers—like investors and financial analysts—do not know how to incorporate climate risks in their models. After a takeover, thus, energy-efficient investments are treated similar to other investments, making it difficult for them to compete. In addition, motivation for energy efficiency technologies at international headquarters may be lacking, resulting in corporate environmental policy that is no longer updated or that is treated as a marketing campaign (F4).

The above dynamics provide an explanation for why only a select group of, mostly Dutch-owned, industrial companies show active interest in IHPs. These companies experience little or no coercive pressure from international headquarters. System functions are mainly fulfilled by this small group of frontrunner companies, making them important TIS actors that set themselves apart from the dominant global regime.

4.3.3. Coercive pressures from activist shareholders

Minority shareholders that put coercive pressure on Dutch industrial companies also create isomorphic behavior in the direction of capitalist logic. For instance, when AkzoNobel rejected three unsolicited takeover proposals from US-based PPG industries, activist shareholder Elliot Investment started a lawsuit with the Dutch enterprise chamber, requesting an extraordinary shareholder meeting where the removal of the chairman of the supervisory board was to be discussed. Although AkzoNobel won the lawsuit, it still felt pressured to sell the specialty chemicals division to create enough shareholder value to repel future hostile takeover proposals from PPG or other international companies. The same applies to the failed takeover of the Dutch–UK MNC Unilever by venture capitalists—the CEO had to refocus from their long-term Unilever Sustainable Living Plan to instead create short-term economic value to satisfy its shareholders, which stood to gain a 30% profit share from the takeover. Similarly, the CEO of Danone was fired by activist stakeholders who did not agree with his sustainability-oriented corporate strategy. Even pension funds—typically considered long-term institutional owners—tend to be governed by daily stock value because they have institutionalized reward systems around short-term profits. In separate interviews, both the Unilever and DSM CEO indicated this coercive pressure is reinforced by normative pressures of the most influential management theory from the past 30 years, initiated by Milton Friedman's famous 1970 essay, "The Social Responsibility of Business Is to Increase Its Profits," which postulates the idea that firms should, above all, focus on creating value for their shareholders. Such dynamics further intensify the fragmentation of the Dutch industrial sector with barriers for the IHP as a result.

There is also an indication of a potential logics change from within the regime. In August 2019, the CEOs of the 181 biggest US companies signed a statement that defined the purpose of a firm, which included a declaration stating that "All stakeholders are essential. We commit ourselves to serving them well, in the interest of the future success of our companies, our communities and our country" [75]. Gartenberg and Serafeim [76, p. 1] considered this a rebuke of Milton Friedman's essay that "helped launch a half century of 'shareholder capitalism.'"

4.4. Response strategies of Dutch TIS actors to global regime pressures

Local actors respond to global regime pressures in various ways. Some responses are aimed at shielding the local environment and actors; others contribute to adaptation to global regime characteristics and, thus, to the further institutionalization of the globally dominant logic to the local one. In the following section, we discuss three illustrative response strategies from our empirical data.

4.4.1. Adaptation response: aligning with global regime pressures

The remaining Dutch-owned companies are now highly aware of the coercive pressures that activist shareholders may place on a company. Because most shareholders (and financial analysts) focus on indicators like quarterly profits, liquidity, and solvability, management feels pressure to also adopt such short-term financial indicators that raise stock prices[7] (F4). Management reasons that if enough shareholder value is created, no far-reaching management changes will be demanded. This leads to increasingly strict budgets, return on investment, and payback-time criteria (F6), even in Dutch-owned industrial companies, hence lowering the demand for IHPs (F5). What companies consider an acceptable payback time currently decreases faster than what IHP performance increases can compensate for. Hence, the adaptation response of process companies exacerbates barriers to IHP diffusion.

The historic focus of Dutch IHP suppliers on offering tailor-made solutions that achieve high efficiencies and temperatures conflicts with the dominant global regime logic. Risk reduction in operations, here combined with a focus on cost competition, has led process companies to demand proven, cheap, standardized, and modular solutions that meet strict investment criteria. Thus, many companies prefer large,

[6] Some venture capitalists are known to buy up companies and squeeze unnecessary and indirect costs out of the company, resulting in direct short-term economic performance increases before selling the company with a profit. This is very destructive for the company's long-term innovation strategies and, hence, competitive position.

[7] To illustrate, a McKinsey study shows that 87% of CEOs feel pressured by investors to show strong financial results within two years and that short-term pressures have increased over time [82].

international technology suppliers who offer such solutions, even though they do not (yet) offer IHPs, especially if they are large enough to share the risks involved. These dynamics have pressured Dutch IHP suppliers to adapt by focusing their innovation efforts on emulating the logic of cutting costs through standardization and modularization (F2). Via this isomorphic behavior, they aim to connect with the global value chain.

4.4.2. *Persuasion response: shielding via normative pressure*

A takeover of a Dutch industrial company division by an international headquarters may lead to strong coercive pressure to institutionalize the capitalist logic, as shown above. However, employees of the Dutch factory remain influenced by the semi-coherence of the Dutch local regime. This leads some Dutch subsidiaries to lobby at the international headquarters for stretching payback-time criteria for energy efficiency measures (F7). Interviewed subsidiaries also state the argument that allowing pilot projects in Dutch factories may, when successful, lead to opportunities for subsequent distribution to other factories worldwide. These discussions are, however, as one interviewee called them, interesting but tough. For now, the normative pressure from the local to the global is weaker than the coercive pressures from the global to the local.

The Dutch government is also following a strategy of persuasion to spread a sustainability logic. It is, for instance, pushing for more stringent CO_2 emission reduction goals and implementation strategies at the EU level and within UN climate talks. In addition, it is trying to persuade other Western European countries to also implement an additional CO_2 tax to maintain a level playing field for Dutch industrial companies. In this way, the Dutch government hopes to improve its competitive position by anticipating an increase in the international institutionalization of the sustainability logic.

4.4.3. *Authoritative response: shielding by mobilizing coercive pressure*

In response to the takeover battle around AkzoNobel, the subject of unsolicited takeovers has attracted the attention of policymakers and politicians to wield their coercive power. The Dutch Minister for Economic Affairs, for instance, called for a waiting period if there is a concrete threat of shareholder activism or a hostile takeover, thereby giving the target company time to assess the interests of all shareholders and respond appropriately. Members of the Dutch Parliament have also called for government action against unsolicited bids on Dutch companies vital for the Dutch economy and employment. The association for institutional investors opposes such a protectionist policy, arguing, here based on the capitalist logic, that the lack of competitive market pressures would make Dutch stock-listed companies lazy. Although such coercive measures may prevent further institutionalization of the capitalist logic within Dutch industrial companies—thus limiting the barriers to IHP implementation—they remain to be taken.

Another less visible coercive response strategy is that of green activist shareholders. In the Netherlands, the organization “Follow This” is pushing for greener strategies by oil and gas companies on behalf of green-minded shareholders. Initially focused solely on the Dutch oil and gas company Shell, it is now also targeting other oil and gas companies. In the US, this strategy is more visible, with organizations like Blackrock and “As You Sow” making use of their shareholder power to pressure companies in a wide range of sectors to reduce CO_2 emissions.

5. Discussion

5.1. *Generalizability, limitations, and further research*

Our findings on the impact of the global processing regime on the Dutch IHP-TIS are summarized in Table 5.1. The table shows that the global processing regime's capitalist logic creates numerous barriers to IHP diffusion, most directly via the system functions “guidance of the search” and “resources mobilization” because the global regime via coercive, normative, and mimetic pressures may define subsidiary companies' innovation budgets and investment criteria. This translates into barriers to innovation that hamper other system functions. Lower innovation budgets, strict payback-time criteria, and risk averseness in technical core processes are barriers not only to the IHP, but to any form of (sustainability) innovation that moves beyond the incremental and is not profitable in the short term. Likewise, the global industry lobby preventing more stringent policy measures for sustainability innovations in processing industries affects all sustainable industrial processing innovations. Thus, the current study contributes to our understanding of the difficulties of decarbonizing energy-intensive

Table 5.1
Overview of the different global regime pressures and their impact on the local IHP-TIS.

Characteristics of the global regime	Isomorphic pressures reproducing the regime characteristic	Impact on the radical innovation
Corporate strategies focus on core activities and competition through market size, while reducing risk in operations	*Coercive*: - Shareholders coerce this strategy on corporate management *Normative*: - Business schools teach this strategy - Competition, here as driven by cost and production volume, reinforces this *Mimetic*: - Consultancies recommend this strategy - Firms successful with this strategy are emphasized	This strategy turns previously vertically integrated companies into highly specialized companies that focus on core activities to compete on market size in narrow but global market segments. This separation of value chains creates substantial coordination problems for the IHP-TIS. Management takes risks on the commercial side and reduces risks in operations, inhibiting innovation in core processes. They focus on cheap, standardized, and modular solutions, which excludes the IHP. However, Dutch IHP suppliers have started to mimic the standardization approach to the IHP. *System functions most strongly impaired*: guidance of the search, mobilization of resources, and knowledge diffusion all feed into weak market formation
Corporate strategies focus on short-term economic valuation and give no priority to sustainability	*Coercive*: - Coercive pressure on subsidiaries from multinational owners - Shareholders coerce this strategy on corporate management *Normative*: - Financial analysts focus on short-term economic valuation, resulting in pressure from the stock market	Management focuses on minimizing costs and risks to optimize short-term economic valuation, leading to cuts in innovation-related personnel and investments. Lack of human and financial resources impairs other system functions for innovations that do not meet strict investment criteria—particularly for sustainable innovations that are no longer strategically preferred *System functions most strongly impaired*: guidance of the search and mobilization of resources feed into weak market formation
Laissez-faire policy focused on incentivizing sustainable innovation instead of forcing it	Coercive-normative: - Powerful industrial lobby for the level-playing field in a globally competitive industry	There is very limited policy support and no enforcement for sustainable innovations. *System functions most strongly impaired*: guidance of the search and mobilization of resources feed into weak market formation

process industries in general—which is a great contributor to climate change that is largely overlooked in transition studies [77].

The global processing industry regime also induces barriers specifically when it comes to innovations that link different segments of the value chain, like the IHP. The regime's focus on core activities, for example, separates industrial value chains and causes coordination problems for new IHP projects, but it does affect modular innovative solutions.

The main contribution of the current paper is, however, in the approach we introduced that allowed us to develop a better understanding of barriers to IHP and of the implications for practitioners. To further this framework, the generalizability of our approach and how coercive, normative, and mimetic pressures affect the interactions between global regimes and local TIS in other sectors and for TIS of other types of innovation needs to be further studied. This further study enables uncovering more "global regime"–TIS interaction patterns and exploring whether the patterns identified in the present study hold for other cases as well. Further research on the impact and prevalence of global regimes in other sectors to explore the reliability and validity of our findings and approach is particularly important given the complexity of global regimes as an object of study. Such complexity generally risks overordering, simplifying multicausal events, and taking theory-dependent biases [78]. Comparative analyses between cases in which emerging TISs are aligned with global regime logics and cases in which they are not will help shed light on the positive and negative impacts that global regimes may have on emerging TIS. Finally, further research may explore the impact of landscape trends [79] on changing global regime logics and the opportunities these trends create for more proactive (discourse) strategies to help institutionalize favorable logics by TIS actors [80].

A major drawback of the current study is the approach's complexity and large amount of data required to analyze a) ideal-type logics of global regimes and how they relate to the TIS's geographical focus (in our case the Netherlands); b) global regime pressures that reinforce the regime; c) the TIS itself; to then d) connect TIS barriers to global regime pressures; and then e) study response strategies of TIS actors to these pressures and barriers. Our approach can be used as a blueprint in further research, but further attempts at "slimming down" the approach would greatly enhance its applicability.

5.2. Implications for TIS actors' response strategies

Our case study illustrated a set of strategies by which TIS actors responded to global regime pressures. Most notable is the adaptation strategy of Dutch IHP producers to mimic the standardization approach to access the global value chain. This finding supports that "mimetic pressures become particularly relevant for peripheral actors that want to gain access to the knowledge, resources, and markets in an existing global production network; often they will have to adapt the local institutional structures and governance arrangements to better fit the dominant MNC's strategic needs" [10,p. 738]. Although this isomorphic behavior increases the Dutch producers' chances to tap into a global market, it also opens their niche position to the competition of more powerful and preferred global suppliers. The question is whether smaller Dutch suppliers can withstand this competition.

Other response strategies are aimed at protecting the local from global pressures, such as the Dutch government's plans to protect companies from hostile takeovers. To protect companies that prioritize societal value over economic performance, (even) the US has developed a special legal status—the "benefit corporation"—that protects these corporations from hostile takeovers. There are over 10,000 benefit corporations, such as Ben & Jerry's. To protect companies in deviating from the global regime logic, such policies differ based on country and could be implemented more widely and homogenously to protect firms that aim to solve societal challenges with strategies that move beyond a focus on the capitalist logic's short-term economic indicators.

Other response strategies are aimed more directly at pressuring the regime to change; these involve normative pressures from local subsidiaries to persuade their global owners to prioritize sustainable innovation, as well as coercive pressures from activist shareholders aimed at the institutionalization of the sustainability logic. Although not prominent yet in the Dutch industrial sector, activist shareholders could play a role in further (re)institutionalizing the sustainability logic within the Dutch industrial sector and possibly beyond. Further research should investigate identifying response strategies that may negate global regime pressures more effectively.

Finally, although many transition studies highlight the role of national governments in steering and facilitating socio-technical and innovation system developments, the current case study shows that the powerful global regime strongly limits what a country can achieve. Not only are firms limited as they strive for access to global value chains, but also, the role of national governments in coercing sustainable innovation is bound by the powerful industrial lobby, along with the fact that firms are increasingly foreign owned and, therefore, difficult to regulate.

6. Conclusion

The present paper has addressed the following question: "How does the global industrial processing regime impact the barriers to the development and diffusion of the IHP in the Netherlands, and how do Dutch TIS actors respond to these impacts?" The case study shows that coercive, normative, and mimetic pressures reproduce characteristics of the global industrial processing regime at the TIS's local level, resulting in formidable barriers to the development—and particularly the adoption—of radical innovations that do not align with the dominant regime logic (see Table 5.1 for an overview). Most of these barriers result from corporate management strategies are pushed by global regime actors. Our framework shows that to fully understand the vastness of the forces underlying the barriers to radical innovation, it is important to study the global regimes at play. It also shows that typical policy interventions to overcome those systemic barriers are likely ineffective because of the regime's change-resisting pressures.

Our case study shows that the global regime is so impactful that the rapid institutionalization of a global regime logic in a certain area can outpace the rate of technological development of radical innovation. To illustrate, the shift in focus from technical efficiency under the engineering logic to economic efficiency under the capitalist logic happened so rapidly in Dutch subsidiaries that the acceptable payback time and risk perceptions as maintained by these potential IHP buyers decreased faster than technological IHP improvements could compensate for, effectively making the innovation *less* attractive over time.

Finally, we find that Dutch actors supporting the IHP-TIS have responded to these regime pressures in different ways, sometimes aligning with the regime via mimetic pressures to access the global regime's market and sometimes in attempting to resist the pressures via normative and coercive pressures of their own. So far, however, these response strategies remain largely unimpactful.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Appendix I

Institutional logics of societal sectors (adapted from [34]).

Categories	Family	Community	Religion	State	Market	Profession	Corporation
Root metaphor	Family as firm	Common boundary	Temple as bank	State as redistribution mechanism	Transaction	Profession as relational network	Corporation as hierarchy
Sources of legitimacy	Unconditional loyalty	Unity of will, belief in trust & reciprocity	Importance of faith & sacredness in economy and society	Democratic participation	Share price	Personal expertise	Market position of firm
Sources of authority	Patriarchal domination	Commitment to community values & ideology	Priesthood charisma	Bureaucratic domination	Shareholder activism	Professional association	Board of directors, top management
Sources of identity	Family reputation	Emotional connection, ego-satisfaction & reputation	Association with deities	Social and economic class	Faceless	Association with quality of craft, personal reputation	Bureaucratic roles
Basis of norms	Membership on household	Group membership	Membership in congregation	Citizenship in nation	Self-interest	Membership in guild & association	Employment in firm
Basis of attention	Status in household	Personal investment in group	Relation to supernatural	Status of interest group	Status in market	Status in profession	Status in hierarchy
Basis of strategy	Increase family honor	Increase status and honor of members & practices	Increase religious symbolism of natural events	Increase community good	Increase efficiency profit	Increase personal reputation	Increase size and diversification of firm
Informal control mechanisms	Family politics	Visibility of actions	Worship of calling	Backroom politics	Industry analysts	Celebrity professionals	Organization culture
Economic system	Family capitalism	Cooperative capitalism	Occidental capitalism	Welfare capitalism	Market capitalism	Personal capitalism	Managerial capitalism

Appendix II

Exemplary quotes that reflect empirical foundation for formulated ideal-type logics.

Engineering logic	“It is almost half a century since historians began to identify the period 1850–1914 as one in which there was, for the first time, a highly productive convergence of science and technology, particularly in Western Europe. That period soon became known in the literature as the Second Industrial Revolution. It was characterized by: (1) Clusters of novel innovations as the core of a new phase of sustained economic growth; (2) The emergence of science-based industrial capitalism, with its hierarchically organized large-scale corporations […]. [83,p. 1] “Endowed with powerful material and human resources, the large conglomerates had developed ambitious research programs that led to spectacular industrial breakthroughs […]. Such breakthroughs were made possible by high-level scientific work and spectacular technological progress […]. Most of these breakthroughs were the outcome of research carried out within industry itself. But scientists were also working in independent research institutes, and, through their fundamental discoveries […] were opening up new prospects […] in both Europe and the United States. Such upheavels knew no frontiers.” [84,p. 168] “America's chemical giants had reached their advanced stage of development because of the long patience of their shareholders and the acumen of their leaders based on thirty years of product and process innovation. Just like their German and Swiss counterparts, U.S. chemical industry leaders had upheld the notion of long-term interest over the more immediate concern of the various types of stakeholders.” [84,p. 330] “The scientific search for new dyestuffs rapidly established synthetic ones produced from coal derivatives as the way forward and institutionalized the science-based innovation pattern that has marked the industry” [38,p. 175]
Sustainability logic	A government official remarked, “There are social changes in the acceptance of environmental impact. How does the company want to profile itself and what does society accept? Energy emissions play an important role in this. The perception of what is permissible has changed.” An industrial company remarked, “The parent company starts to ask questions because they want to be included in the Dow Sustainability Index.” A subsidiary of international conglomerate said, “The director considers sustainability important but no company-wide goals have been set. […]” “Where once black bellowing smoke from factory chimneys was associated with prosperity and economic growth, and the proximity of a fast flowing river for use as a waste sink often dictated plant location, today it is the price of historical releases to the ground, to the atmosphere and to surface waters that commands our attention.” [83,p. 5] “This development has shown that it is possible to develop and market renewable chemical products, although it is still a niche product in a market completely dominated by fossil-based production.” [38]
Capitalist logic	“The expansion of stock markets, with the increased interest paid to profitability by financial analysts, pension funds, managers, and individual investors in the Western world, has given prominence to the concept of ‘share value.’” [84,p. 404] A subsidiary of international industrial company stated, “If we talk in ‘euros’ then management is happy.” “[…] the growing influence of financial analysts on the behavior or shares quoted on the Stock Exchange, and the arrival at the head of the large industrial groups of graduates from glamorous business schools trained more in finance than in technology gave the scene a new twist. Shareholders were more interested in the instant profits they could draw from breaking up a group than with the added value that could be patiently built up through its development.” [84,p. 331–332] A professor energy, resources and technological change noted, “This general trend originates from business schools everywhere in the world. […] here the focus lies on expansion (higher investments and more risk to increase market share) and much less on energy. […] Budgets are distributed irrationally and this can only be explained by this thought of expansion from business schools. This is reinforced in strongly global sectors, with high investments and commodity/price-oriented competition.”

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Appendix II (*continued*)

	An industrial cluster said, "If you set up your plant here, you can fully focus on your core business. There is a wide range of service and utilities, and so forth available to cover all your operating activities, with an excellent price, quality ratio."

Appendix III
Exemplary quotes for barriers to IHP implementation in the Netherlands.

System function:	Barrier:	Exemplary quotes (English):
F1/F2	Hard to find locations for research and demonstration projects	• Engineering firm: "Many companies do not want to be a testing ground, so you have to look for demonstration opportunities."
F1/F2/F3	Innovation projects and external collaborations are halted after the divisions of Dutch industrial companies are taken over	• Former division Dutch industrial company now partially owned by private equity firm: "In the past, we were [involved in external collaborations or innovation projects], under [Dutch industrial company], but now [under private equity firm] less so. Projects with external partners were carried out within the [Dutch industrial company]."
F2	Thus, Dutch IHP suppliers' innovation efforts are increasingly aimed at emulating the rationality of cutting costs through standardization and modularization (F2).	• Consultant: "Technology suppliers must (from client) offer cheap and then come up with standard solutions." • Dutch heat pump supplier #2: "By applying modular heat pumps and smart designs the price is greatly reduced. The goal is to achieve around 250 euro per kW and a payback time around three years."
F3	Coordination problems	• Former division of a Dutch industrial company now owned by international conglomerate: "Yes, [heat management] with external parties is more difficult to organize and difficult in terms of contracts. External usage [of waste heat] is seen more as risk than as opportunity."
	Low involvement of companies within discussion platforms for energy efficiency. Companies do not come to meetings or conferences where the IHP is discussed.	• Industrial company partially owned by private equity firm: "[…] there has never been a meeting [on energy management in the cluster] where everyone involved was present." • Formed division Dutch industrial company now owned by international conglomerate: "There is limited knowledge exchange between parties in the region."
	After takeovers, companies do not continue internal networks discussing energy efficiency.	• Industrial company partially owned by private equity firm "Within DSM there was a platform for energy. That has disappeared in the current conglomerate. Replacing it would be welcome."
	Little time for evaluation and sharing of project results	• Consultancy report: "Often, after a project ends, there is little interest in evaluation, even though experiences may be very important for sister companies (and suppliers)."
	Industrial companies are not familiar with the capabilities of technology suppliers	• Dutch industrial company: "Engineers and operators do not understand what a heat pump does." • Dutch Heat Pumping Journal: "Most firms are not aware of the technical possibilities of waste heat utilization."
	Companies do not have the knowledge in-house to implement a heat pump (F3)	• Dutch subsidiary international conglomerate, former division of Dutch company: "We have no idea how to electrify our process."
F4	Motivation for energy efficiency technologies at international HQs may be lacking, resulting in corporate environmental policy that is no longer updated or that is treated as a marketing campaign	• Former division of Dutch industrial company now partially owned by private equity firm: "One and a half years ago, we transferred from [Dutch industrial company] to [International conglomerate]. Within [Dutch industrial company], energy targets were imposed. To contribute to that, a start was made with creating programs and projects for energy saving to achieve the overall targets in 2009 and 2010. Energy reduction of 20% between 2008 and 2020 was the goal. […] There is currently no effective attention for replacing the old [Dutch industrial company] targets for energy saving."
	Dutch subsidiaries need permission for investment decisions from their international headquarter	• Sector association: "[Industry] is for investments dependent on mostly foreign owners."
	Environmental sustainability moves down on the priority list after a takeover	• Former division of Dutch industrial company now partially owned by private equity firm: "Strategic choices come first and projects are started and implemented until the investment budget is spent or allocated. Top projects must have a payback time between zero and two years. For energy efficiency projects, it is very difficult to end on top. … The primary incentive in the company is on products, energy follows [not energy efficiency]."
	Because most shareholders (and financial analysts) focus on indicators like quarterly profits, liquidity and solvability, management feels mimetic pressure to also steer on such short-term financial indicators that drive up stock prices	• Dutch company: "Shareholders put pressure on investment policy—the 2015 annual report shows that a lot has been invested in capex. Shareholders naturally expect a certain return from this."
F5	Industrial companies thus rely on consultants or engineering firms to come up with the best solution, but the heat pump is not always offered (F5)	• Engineering firm: "The client wants to see solutions and [consultant name] is expected to advise the best solution. It is nice to have the heat pump in the range of options, but it is not there now."
	Low demand for heat pumps	• Technology supplier: "Engineering firms are also not able to actually sell the technology."
	Low demand for technologies that touch the core process	• Consultant: "Companies all say: do not touch my process." • Engineering firm: "The primary process must stay operational. If the heat pump has a small chance of failing for a longer period, it is no longer considered a serious option."
	IHP suppliers no longer know who to approach in the Dutch subsidiary factory to sell their IHP	• Network organization: "Suppliers usually do not know whom to turn to in the process industry. It is certainly not the purchasing department."

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Appendix III (*continued*)

System function:	Barrier:	Exemplary quotes (English):
	To further reduce risk, industrial companies work with a small number of preferred suppliers. Generally, these are the large international technology suppliers that can share in the risk involved with new technologies. As a result, smaller-scale heat pump suppliers that create tailor-made solutions have a hard time selling their solutions (F5)	• Dutch heat pump supplier: "[Technology supplier] has a turnover of 400 million euro as a group. In the Netherlands, we are one of the largest suppliers for cooling technology. Still, we are not taken seriously for heavier projects. Why? Because you are not large enough or cannot bear liabilities."
F6	International companies have made daughter companies so 'lean' that there is little capacity for employees to do innovative projects, who subsequently resist 'additional work'	• Engineering firm: "Another barrier is found in companies that are made entirely lean and no longer have time to work on new options. […] there is not enough time in the organization to supervise the projects."
	The financial benefits of an IHP often cannot be monetized	• Sector association: "Yes, there are always 'marriages' in the energy supply between industrial companies in which changes occur along the way: between partners, with the children, and so forth. Because it concerns long-term contracts, this results in difficult adjustments. […]"It [a heat pump] has to fit within long-term contracts: purchase and sale of energy."
	After a takeover, budgets are often tightened and strict return on investment, and payback-time criteria are dictated by the investors or parent company that the IHP does not satisfy (F6) It is not uncommon that only investments with a payback time below two years are funded, even though energy efficiency projects with a payback time of less than five years are obligatory by Dutch law (F6)	• Dutch subsidiary large international conglomerate, former division of Dutch company: "[Dutch subsidiary] really wants to and it is obligated by law (payback time below five years). However, the parent company tightens the reins so there is no room for investments with a payback time over ∼1 year."
	In Dutch-owned industrial companies as well, budgets, return on investment and payback-time criteria become increasingly strict (F6)	• Dutch company: "In general, there is a lot of pressure on investment decisions – the accepted payback time is getting shorter and shorter."
F7	Dutch subsidiaries to lobby at the international headquarters stretching up payback-time criteria for energy efficiency measures.	• Dutch subsidiary international conglomerate, former division of Dutch company: "Discussions about stretching up payback time criteria are interesting but also tough conversations."

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