WORKING PAPER

How global socio-technical regimes affect the success of low carbon innovation – The case of the industrial heat pump

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Abstract

This paper analyzes the impact of globalized industries on the diffusion of promising radical low carbon innovations. We do so by studying the interplay of global socio-technical regimes and technological innovation systems (TIS). Building on institutional theory, we develop a theoretical framework for TIS-regime interaction and apply it to the case of the industrial heat pump (IHP) in the Netherlands. Based on a qualitative, historical analysis over the past 30 years, we show how the heat pump TIS is at odds with the global process industry regime and identify several mechanisms through which the regime's coercive, normative and mimetic institutional pressures influence TIS dynamics. We furthermore discuss how 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 even though the technology's performance increases. The paper thus provides a better understanding of the effects of global sectoral structures on radical low carbon innovation in particular places and industries. It offers valuable insights into the dynamics of sustainability transitions, especially in regard to the (limits to) effectiveness of policy interventions geared towards a particular TIS at the national level.

Highlights

- A global regime can hamper TIS development via coercive, normative and mimetic pressures
- These pressures stem from the regime's institutionalized logics that are incompatible with the TIS
- The institutionalization of a new logic can outpace technological development, making a technology less attractive over time
- TIS actors' response strategies to global regime pressures are largely ineffective

Keywords: sustainability transitions; global regimes; technological innovation systems; institutional logics; institutional isomorphism; isomorphic pressures

1. Introduction

Research on the dynamics of sustainability transitions led to the development of several theoretical frameworks to understand why radical, low carbon innovations are slow to break through. These frameworks understand the development and diffusion of a radical innovation, very often a new technology, as the outcome of co-evolutionary processes within socio-technical systems that comprise actors, networks and institutions.

The Technological Innovation System (TIS) perspective and its structural-functional approach is particularly acclaimed for identifying the drivers and barriers to the development and diffusion of novel technologies. However, it has been increasingly criticized for under-conceptualizing the contexts within which TIS emerge (Bergek et al., 2015; Markard et al., 2015). Attempts have therefore been made to reconcile the TIS perspective with concepts borrowed from other theoretical frameworks. One of the most promising ones is the notion of socio-technical regimes, which is used to describe the dominant rules of the game of an established system that are restraining the TIS of radical innovation (e.g. Markard and Truffer, 2008; Meelen and Farla, 2013).

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 (Coenen et al., 2012) has shifted attention to understanding where socio-technical regimes develop and where they have impact, accounting for the highly uneven geographical dynamics of many transitions. On the other hand, regimes have been conceptualized as institutional rationalities in order to account for their rule-like character (Fuenfschilling and Truffer 2014). Taking into account both these theoretical developments, Fuenfschilling and Binz (2018) introduced the concept of the global socio-technical regime. They highlight the multi-scalar characteristics of socio-technical regimes and show that the globalized nature of many industries leads to globally shared rules of the game that can have very different effects in specific places.

While the global regime framework is a promising framework to better understand 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 technological development and it is unclear to what extent regions or countries can deviate from these global pressures and instead foster niche innovation (Schot and Geels, 2007; Sengers and Raven, 2015). In this paper, we therefore 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 origin (DiMaggio and Powell, 1983; Meyer and Rowan, 1977). By studying how a TIS is affected by such isomorphic pressures, we are able to contribute to a better understanding of the concrete impacts of global regimes on 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). Industrial processing of materials like chemicals and food accounts for 42% of CO₂ emissions in the Netherlands (Roelofsen et al., 2017). The IHP has potential to contribute to reducing these emissions, but despite substantial TIS developments over the past decades, the technology is unable to break through, in the Netherlands and beyond. With our study we show that the reasons for this lie in the powerful global industrial processing regime.

The remainder of this paper is structured as follows. The theory section links the TIS literature to the concept of a global regime and of isomorphic institutional pressures to establish a framework on how global regimes may impact radical innovation. The methodology section introduces the case and describes the methods of 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 local Dutch TIS can be assessed via a complementary structural-functional analysis. We also

identify various response strategies by local TIS-actors. The paper concludes with a discussion on the theoretical framework and offers thereof resulting policy implications.

2. Theoretical framework

2.1 Global socio-technical regimes

The concept of the socio-technical regime has been developed to understand the stability of existing socio-technical systems (Rip and Kemp 1996). It conceptualizes the overarching rules stemming from the co-evolution of technologies and institutions over time in a given sector. 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”* (Geels, 2002, 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”* (Fuenfschilling and Binz, 2018, p.738; Sewell, 1992). Regimes are thus commonly assumed to 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 research increasingly focusing on the geography of transition (Coenen et al. 2012), scholars have started to pay attention to where these rules of the game develop and where they have impact. For this purpose, Fuenfschilling and Binz (2018) introduced the concept of the global socio-technical regime. The underlying idea is to acknowledge the increasingly globalized nature of many industries and its institutional effects in specific places. The authors propose that dominant regime rationalities are diffused at a global scale, as they are enacted and maintained by globally active nation states, multinational corporations (MNCs) and intergovernmental organizations (IGOs) that wield military, economic and political power, and by international non-governmental organizations (INGOs) and social movements that wield cultural power (Fuenfschilling and Binz, 2018). The authors combine insights from organizational institutionalism, especially world polity studies and writings on institutional isomorphism (Meyer et al. 1997; Meyer and Rowan 1977) with the Global Production Network and Global Value Chain perspectives (Coe et al., 2004; Levy, 2008; MacKinnon, 2012; Yeung, 2009), in order 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”* (Fuenfschilling and Binz, 2018, p.739). Institutional rationality is thereby operationalized using the concept of institutional logics (Friedland and Alford 1991; Thornton and Ocasio 2008). Logics 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”* (Lounsbury et al. 2002, p. 328).

It is suggested that western societies typically consist of a few dominant institutions that each come with their own very ideal-typical institutional logic, i.e. 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, the community, the religion, the professions, the state, the corporation, and the market (Thornton et al., 2012; 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 logics and thus develop a unique institutional logic of its own that guides cognition and behavior (Fuenfschilling and Truffer, 2014).

The influence of each logic is dependent on the degree of its institutionalization (Berger and Luckmann 1969). The more a logic is institutionalized, i.e. 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 will unfold (Fuenfschilling 2019). Of particular importance for the purpose of this 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 the more radical innovations tend to function under a very different logic than the established system, we expect to find a fair amount of tensions between the institutional logics of the global regime and those of the emerging TIS.

To our knowledge, there are currently only a limited number of studies that have investigated multi-scalar regime dynamics. While Fuenfschilling and Binz (2018) apply the concept of the global regime on a case in the water sector, showing how the global regime heavily shaped the development of the Chinese water sector, Bauer and Fuenfschilling (2019) studied how the global regime in the petrochemical sector has hampered the development of sustainability initiatives in the chemical sector in Sweden. In both cases, however, there is no thorough conceptualization of the specific institutional pressures exerted by the regime, and neither of the local context that is affected by these pressures. In particular, there is no clear evidence on how a global regime affects innovation activities and how actors react to pressures from global industries. In the next sections, we will thus introduce the concept of the TIS and outline 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*” (Carlsson and Stankiewicz, 1991, p.93). Notably, the structural-functional approach has proven an adequate ‘focusing device’ for identifying the weaknesses or systemic problems in a TIS (Wieczorek and Hekkert, 2012). 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 problems.

System function & 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 towards 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

Table 2.1, Overview of system functions, based on Hekkert et al. (2007)

The TIS approach has been criticized, however, for under-conceptualizing contextual structures (Bergek et al., 2015; Markard et al., 2015). Notably, the TIS is perceived by some as inward oriented and paying insufficient attention to the underlying nature of systemic problems that emerge from the system's environment (Markard and Truffer, 2008). Although recent contributions have created a deeper understanding of the underlying causes of systemic problems, of their interrelatedness and how this can amount to systemic lock-in (Kieft et al., 2017; Wesseling and Van der Vooren, 2017; Bergek et al., 2015), TIS still misses an understanding of *why and through which mechanisms* incumbent systems inhibit TIS development.

At the same time, TIS tends to overlook geographical contexts due to its history of methodological nationalism (Binz and Truffer, 2017; Coenen et al., 2012; Gosens et al., 2014; Markard et al., 2012; Schmidt and Dabur, 2014). However, even with a national focus, TIS studies need to understand the innovation processes that take place at the global level. TIS do not have to be developed 'fully' within one nation. Instead, international linkages between TIS-structures become crucially important as innovation has become increasingly a global phenomenon (Binz and Truffer, 2017; Coenen et al., 2012).

We suggest that to overcome both these contextual weaknesses, TIS can be fruitfully studied in the context of *global regimes*. Such a 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 therefore outline the institutional pressures through which a global regime may impact TIS developments.

2.3 The impacts of global regimes on radical innovation by TIS

The development of radical innovation has been seen as crucial for any kind of sustainability transition (Köhler et al., 2019; Markard et al., 2012). To better understand the impacts of global industrial structures on radical innovation, we propose to take a closer look at how global regimes affect the development of TIS. Places with cultural, institutional and material preconditions that deviate from those of the global regime are assumed to pose breeding grounds for new institutional logics as they have the potential to establish new, more sustainable socio-technical configurations (i.e. niches) (Schot and Geels, 2008). It is here that TISs around alternative technologies may emerge (Markard and Truffer, 2008). However, the institutionalization of a TIS occurs in close interaction with existing structures, i.e. with the regime. As a TIS develops into a more stable configuration, the often striking mismatch between TIS and regime logics becomes increasingly apparent. Consequently, TIS development is expected to experience increasingly substantial barriers, mainly due to hampering institutional pressures exerted by global regimes.

Following institutional theory, we posit that global regimes maintain their rationality through three particular isomorphic institutional pressures: coercive, normative and mimetic (Dimaggio and Powell, 1983; Meyer and Rowan, 1977). Below we illustrate how these pressures, 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 favour regime practices, like 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 (Coser et al., 1982; Dimaggio and Powell, 1983). The literature on institutional ownership shows that the same applies to powerful shareholders (Cox et al., 2004; Neubaum and Zahra, 2006). Mutual funds and investment banks, as opposed to pension funds and state investors, often pressure firms to focus on short term economic valuation, cutting expenses in innovation and corporate social responsibility as a result (Ibid.). 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') radical innovation (Cox et al., 2004; Neubaum and Zahra, 2006; Pfeffer and Salancik, 1978). Finally, large, multi-national companies can exert coercive and normative power on governments against regime-destabilizing policies, particularly when they form a closed industry front (Fligstein and McAdam, 2011; Hillman and Hitt, 1999; Lawrence and Suddaby, 2006; Wesseling et al., 2014).

Normative pressures are mostly associated with 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 into an epistemic and professional community (Dimaggio and Powell, 1983; Meyer and Rowan, 1977). For example, managers that share educational backgrounds (which is often an important selection criterium for higher management positions) or other communities, tend to view problems and solutions in similar ways (Ibid.). This manifests in their management strategies which reflect the regime logic as opposed to that of the TIS. Finally, voluntary industry standards have been shown to effectively maintain the status quo as new products like LED lamps (Smink et al., 2015) and alternative construction materials (Wesseling and Van der Vooren, 2017) may be incompatible with such standards.

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 (Dimaggio and Powell, 1983; Cyert and March, 1963). Sustainability brings about such uncertainty and causes firms to mimic successful actors, which are typically regime actors that exploit the low hanging fruits of incremental innovation (Perez-Batres et al., 2011). Fuenschilling and Binz (2018, p.738) argue 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 powerful global firms that dominate these global value chains. This means that the radicality of the TIS' innovations may be lost as TIS actors are pressured to 'fit and conform' their innovations to the global regime's selection environment (Smith and Raven, 2012; Wesseling et al., 2020). Multinational consultancies are also a strong force of mimetic pressure, as they tend to recommend similar organizational models and technological solutions to their customers and demand for their services is highest during times of uncertainty (Dimaggio and Powell, 1983; Fuenschilling and Binz, 2018). Since 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, strategic consultation), it could have a profound effect on different parts of the emerging TIS.

The global regime's three isomorphic pressures thus often result in the maintenance of the status quo, i.e. in the reproduction of the regime and its spreading across space, which is expected to pressure the TIS in various ways. Table 2.2. provides an overview of the institutional pressures and expected impact on the TIS. The aim of this paper is to empirically explore to what extent we can retrace these different pressures and the barriers they pose to TIS expansion, including analyzing responses of TIS actors to those pressures.

Isomorphic global regime pressure:	Expected impact on TIS:
<i>Coercive pressure</i>	Through <i>direct authority</i> , conglomerates are expected to enforce management decisions on subsidiaries that impair TIS-technology development and adoption, as do shareholders enforce such decisions on corporate management.
	Through <i>buyer or supplier power</i> , 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 impaired by coordination issues and the <i>powerful lobby</i> of the global industry.
<i>Normative pressure</i>	<i>Dominant educational logics</i> , which may not be in line with the TIS logic, are reflected in corporate and public management
	<i>Voluntary standards</i> may inhibit radical innovations

<i>Mimetic pressure</i>	Radical innovations are pressured to <i>fit and conform</i> to the regime's selection environment
	Multinational <i>consultancies reproduce</i> the regime's corporate and public management logics, which may not be in line with that of the TIS

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

3. Methodology

Our empirical analysis centers around a qualitative, explorative case study of an innovation with a potential to improve energy efficiency across a variety of industrial processes: the industrial heat pump (IHP). The study entails an analysis of the historical development of the global regime of the process industry, i.e. the sector where the IHP could potentially bring substantial sustainability gains. It furthermore entails an analysis of the IHP-TIS, with a specific focus on the Netherlands. We then reconstruct the institutional pressures from the regime onto the TIS and portray some responses to those 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 medium. 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 and thus significantly contribute to reducing industrial CO₂-emissions. In Europe alone, 3.803 potential locations for IHP have been identified, representing a total potential of up to 22% of heat demand under 200C in chemical, refinery, paper and food industries (ECN, 2018). The most common IHP, currently in the beginning of the take-off phase, is the so-called compression heat pump for heat sink temperatures of up to +-110C. It is currently applied in niches, especially in the food industry. Compression heat pumps using alternative working fluids to achieve heat sink temperatures up to +-180C are still in the pilot phase, whereas alternative versions like the chemical heat pump and the thermo-acoustic heat pump are in earlier phases of development. These alternative heat pumps have the potential to reach temperatures of up to +-250C, thereby coming into the range of lower temperature chemical processes.

The IHP is produced by specialized technology suppliers providing (energy efficiency) 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 who are organized in industrial clusters. Dutch knowledge institutes and heat pump providers work closely together in research and development, providing tailor-made solutions. They are amongst the world leaders in heat pump technology. However, despite all these activities and the great potential of the technology to achieve sustainability gains, the diffusion of heat pumps across industries has been difficult. This can be explained when taking a closer look at the nature of the corresponding global regime of the process industry and the associated pressures on the TIS.

3.2 Research design and analytical approach

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

3.2.1 Data collection

Our data comprises a wide range of qualitative sources, of which 34 interviews with industrial companies, technology suppliers, consultants and government officials form the basis (see Table 3.1

for an overview). These interviews were transcribed and supplemented with public reports on IHPs, policy documents on current and past policies, and notes made during meetings of industrial professionals (e.g. conferences and workshops). These data sources were bundled in a digital database and subsequently coded and analyzed using the Computer Aided Qualitative Analysis Data Software NVivo.

Data sources	Amount	Corresponding 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

Table 3.1, Overview of data sources

3.2.2 Data analysis

The first part of the analysis entailed the identification of institutional logics in the process industry over time. For this purpose, we used the ‘pattern matching’ technique (Reay and Jones, 2016). 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 process. Instead, the process towards understanding requires deliberate simplification so that patterns become visible (Weber, 1922). 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. For this paper, three ideal-type logics were formulated on the basis of a historical analysis of the global processing industry. 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 (4.1.2) and the institutionalization of these ideal-type logics in the Netherlands (4.2.1). Appendix II provides exemplary quotes that reflect the empirical foundation of these ideal-types. Appendix III lists practices, regulations, policies and noteworthy historical happenings that provide indicators for the degree of institutionalization of the logics in the Netherlands.

The second part of the empirical analysis was geared towards the identification of institutional pressures from the global regime onto the Dutch TIS (presented in section 4.2.2). For this purpose, we performed a structural-functional TIS analysis on the development and diffusion of the heat pump in order to identify systemic problems, and their interrelatedness (see Kieft et al., 2017; Wesseling and Van der Vooren, 2017). The analysis is based on open coding (Strauss and Corbin, 1998) of textual fragments. Coded fragments were first allocated to the respective system functions, and later grouped into categories according to the guidelines on focused coding (Charmaz, 2006). Data collection continued until new data no longer led to changes in the categories, i.e. until theoretical saturation was achieved. Categories that related to the international context were subsequently classified as a type of isomorphic pressure (mimetic, normative, coercive) they were emanating on the Dutch context. Responses by Dutch actors to these isomorphic pressures were also classified as either mimetic, normative or coercive (section 4.4).

Finally, we linked the systemic problems identified in the Dutch context to the types of isomorphic pressures emanating from the global regime (section 4.3). This was done based on what

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 would explain how the fragmented nature of Dutch industrial clusters inhibits IHP implementation, whereas other data shows how the global regime logic drove fragmentation of Dutch industrial clusters. Only the systemic problems that were found to be directly or indirectly the result of the global regime’s isomorphic pressures were included in analysis section.

4. Results

4.1 The global regime of the process industry

In what follows, we present our historical reconstruction of different ideal-type institutional logics in the processing industry and their relative importance over time. For the purpose of readability, instead of inserting the numerous sources on which this narrative builds, Appendix II as well as several footnotes provide an overview of exemplary quotes from various sources that reflect the empirical foundation for the following description.

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

The process industry was built on a foundation of the institutional sector logics of the profession, corporation and state. Broadly speaking, scientific and technical ingenuity have been highly valued in society since the Age of Enlightenment, which had led to numerous scientific and technical breakthroughs. Due to the close ties between industry and universities at the time of the industrial revolution, the striving for personal reputation that characterises the scientific field was also felt in the emergent process industry. For instance, not only newly-developed chemical processes and techniques were named after their inventors, but also many industrial companies¹. For the emerging sector, the main basis of strategy was to profit from these breakthroughs. Through the combined influence of the corporation and the state sector logics, both privately owned and state owned companies sprang up. Within these companies, the main mission became to develop new chemical processes, materials and technologies on the basis of scientific and technical expertise. These companies emerged around places of abundant natural resources that were necessary for the 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 ‘*engineering logic*’, anchored in the institutional sector logics of the profession, corporation and state, became dominant internationally (see Table 4.1).

Since scientific and technical breakthroughs came from Europe during the industrial revolution and later the United States, 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 19th century, exporting their products all over the world. After the second world war, while European companies were recovering, the US took over as leading industrial innovator². As international markets opened up, investment capital could more easily circulate among countries. This led the industrial giants to establish international production units, thereby becoming truly multinational companies. When these multinationals kept diversifying into new markets that opened up through their inventions, they turned into international conglomerates.

Over the course of several decades after the second world war, a shift took place in the direction of the market logic at the expense of state and profession logics. The new ‘level-playing field’

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

² in part due to German patents being confiscated by the allied forces.

that was created after international markets opened up substantially increased competition, at a time that the conglomerate expansion had led to overcapacity in commodity markets. Global competition was further exacerbated as Asian and Middle Eastern companies gained a foothold in the global market. Competition from these newcomers increased most in the bulk commodity markets as those processes were technologically less advanced. Now that economic performance as a result of pursuing new innovations was no longer guaranteed, remaining profitable became a mission in itself.

Increasing profit margin³ became the leading basis for company strategy of western firms in the process industry. This was achieved not only through decreasing costs and divestment of less profitable activities (e.g. commodities), but also through pursuing activities in areas with potentially higher margins (e.g. fine or specialty chemicals), the latter often through acquisitions. In this way, the new norm became to reduce costs and risks on the production side while taking risk on the commercial side (acquisitions). Companies focused their attention on core activities, selling less profitable divisions to other companies, private equity firms or entrepreneurs. Buyers were herein facilitated by newly developed corporate financing strategies, like the leveraged buyout model. Maintenance and utilities activities were also often considered non-core and divested. This latter development made industrial companies more dependent on suppliers for new technologies and innovations. As industrial companies prefer standardized lowcost-solutions, technology suppliers that offered such solutions became successful. As a result, the western conglomerates turned into highly specialized companies that compete through market size in a narrow value chain segment.

As economic expertise had become more important, technicians in management had been replaced by economists who were trained in economic theory and had affinity with financial indicators. This coincided with a surge in both privately owned companies and state-owned-enterprises becoming listed on stock markets, thus making shareholders a main source of authority. Financial analysts, who focus on short-term indicators like quarterly profits, liquidity and solvability, now formed a new informal control mechanism. That companies had a stock-market listing also opened up 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 margin through further decreasing costs or intensifying divestments. In addition, 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 parts for a profit. Through these developments, the ideal-type *capitalist logic* (originating from the market/corporation sector logics) became the dominant logic in the industry, at the expense of the engineering logic.

Furthermore, a third ideal-type logic addressing environmental sustainability concerns is currently developing at the periphery of the sector. The sustainability logic can be interpreted as having its roots in the institutional logics of the community and the 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 international process industry. It was a wake-up call for national governments and industrial companies worldwide, leading to improved plant safety around the world. Although climate change as community concern has been advocated by scientists since the seventies, the EU CO₂ trading scheme (EU ETS) initiated in 2005 marked the first time the process 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 due to cut-throat 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 but instead voluntary agreements were the default policy instrument in nations worldwide. Although the EU ETS has increased in stringency, it still largely protects basic processing industries in order to maintain their economic activities within Europe, for instance through free CO₂-emission rights for the majority of production volume and through financial compensation for the 'administrative burden'.

³ "The market is thus dominated by price competition and firms engage in cost leadership strategies which guide their innovation initiatives (Albach et al., 1996); Ren, 2009)" Bauer and Fuenfschilling (2019).

With the Paris agreement, signed in 2015, member states worldwide committed themselves to the creation of national climate action plans that will affect industrial companies world-wide, thereby potentially strengthening the influence of the sustainability logic⁴. Since the process industry is dominated by companies, the main mission is to achieve CO₂-reduction in a cost-effective way. This necessitates not only a combination of both technical and economic expertise, but also a focus on both the most CO₂-efficient and cost-effective technologies. Risk taking in operations is deemed necessary to achieve CO₂-reductions, 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.

Table 4.1: ideal-type logics in the industrial sector.

	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

4.1.2 Fit of industrial heat pump with global regime logics

By reaching technical efficiencies of multiple hundred percent, the IHP is a poster-child technology for the *engineering logic*. Tailor-made designing the heat pump to local conditions increases the achieved temperature rise. This, and integration of the IHP within the industrial process requires technical expertise and ingenuity, as well as risk taking in operations – all preconditions in line with the engineering logic. Furthermore, 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 two industrial processes. Larger conglomerate industrial companies that operate numerous industrial processes at an industrial cluster and have remained utilities in-house therefore offer most potential for industrial heat pump implementation.

Under the *sustainability logic*, it is the CO₂-efficiency of the IHP that comes into focus. Although the IHP certainly reduces CO₂-emissions, determining how much is not straightforward since it depends not only on how the heat is produced at the plant, but also on how the electricity for the compressor is produced. In addition, for achieving CO₂-reduction, the IHP is in competition with a multitude of technologies including alternative industrial processes, carbon capture and storage (CCS), electric boilers and district heating networks, of which the latter three do not require adaptations to the core industrial processes. However, since risk taking in operations is considered acceptable under the sustainability logic, both standardized and tailor-made IHP's remain competitive in niches.

⁴ The United States decided to withdraw from the Paris Agreement in 2019 and the Madrid convention led to a 'minimal' agreement.

Although the IHP is no longer the poster-child technology, it does have the potential to thrive when the sustainability logic becomes institutionalized.

Under the *capitalist logic*, implementation of an innovative technology only adds value when the short-term economic performance (profit) 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. In addition, there will be a strong preference for standardized technical solutions that do not touch core industrial process (due to risk reduction in operations). Hence, the IHP does not fit well with the dominant capitalist logic.

In the next section, we elaborate the main dynamics through which the capitalist logic is being institutionalized in the Netherlands and how this has led to implementation barriers of IHPs. Before diving into detail on this aspect, the historical institutionalization of the three ideal-type logics in the Netherlands is discussed.

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 the 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 the *capitalist logic*. A few years later, due to margin pressure in bulk chemicals, DSM also divested out of bulk chemicals to focus on the new core-areas of nutrition and performance materials. Increasing global competition in bulk fibres since the 1970s drove Akzo to refocus further, on the core areas of paints and specialty chemicals. Through strategic mergers & acquisitions both AkzoNobel and DSM remained successful as R&D-focused industrial companies in a few highly specialized market segments. Also elements of the sustainability logic are present as bonuses within DSM are for instance related to both financial and environmental sustainability in equal measure since 2010 and both companies had mid-term CO₂-reduction targets. 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 in the Netherlands come out of the periphery. Already since 1992, the Dutch government has made multi-year agreements with the process industry to aim for reductions in energy use through increasing energy-efficiency. However, the main aim thereby 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 pay-back time under five years became obligatory, but these were hardly enforced. The Dutch Energy agreement was signed in 2013 as answer to the goals from the 2012 European Energy-Efficiency Directive to reduce energy-use by 20% by 2020. Since 2010, the Dutch government has also given out large R&D subsidies under the umbrella of the Topsector approach to stimulate technological innovation to support reaching these goals. These subsidies have helped Dutch technology suppliers and research institutes become leaders in tailor-made energy-efficiency innovations, including the IHP. CO₂-

reduction was also achieved during this period, but as an indirect result of the striving for improved international competitiveness of Dutch technology suppliers and industrial companies.

Since the Paris agreement was signed in 2015, attention for CO₂-reduction as main goal has gained a foothold. To concretize the Paris Agreement, in 2018 Dutch actors started negotiating a Climate-agreement with the goal of reducing 49% CO₂ by 2030. The process industry was expected to contribute with a reduction of 14,3 megatons CO₂. The industry lobby for maintaining an international level-playing-field was strongly felt during these negotiations, although not all industrial companies acted equal in this respect. Some, including Shell, for instance sent an unusual letter to the government asking for a strong climate law. After fierce debates, the industry-led coalition of companies presented a draft Climate agreement to the national government, consisting mainly of obligatory CO₂-reduction plans for companies in return for large subsidies. However, not convinced of the effectiveness of this approach, government presented a strongly modified Climate agreement on June 28th of 2019. In this latter agreement, the mandatory CO₂-reduction plans were replaced with a national CO₂-tax that acts as a floor on the EU-ETS price – Corona has however postponed implementation of this policy by four years. All Topsector policies and subsidies are being brought in line with CO₂-reduction as main goal. Specifically relevant for the IHP is the initiation of a large-scale subsidy program (SDE++) that intends to close the gap between the payback time of CO₂-reduction measures and the five year payback time required by law. 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.

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

Engineering logic	Sustainability logic	Capitalist logic
<ul style="list-style-type: none"> • Dutch industrial companies still compete on science-based innovations • Technology suppliers & research institutes are leaders in tailor-made innovations 	<ul style="list-style-type: none"> • CO₂-reduction as main goal in Climate Agreement • Potential CO₂-reduction as criterium in subsidy schemes • Industrial companies sending letter to government asking for stringent environmental policies • Energy-efficiency measures with payback time under 5 years are obligatory • Increase of law enforcement • National CO₂-tax • Separate budgets for sustainability and energy-efficiency measures • Bonusses of boards of directors depend on achieving both financial and environmental targets 	<ul style="list-style-type: none"> • Foreign activist shareholders • Attention for 'level-playing-field' in Climate Agreement • Split of Akzo Nobel • Selling of non-core activities by Akzo Nobel and DSM • Lobby for 'level-playing-field' during Climate-agreement negotiations • Focus on achieving economic growth • Sustainability programs are no longer updated after taken over by international company • Discontinuation of internal discussion networks / platforms that discuss energy-efficiency • Little room for investments in industrial companies

4.2.2 Fit of industrial heat pump TIS with Dutch regime

The result of the Climate agreement is a comprehensive set of measures that strives to stimulate CO₂-reduction technologies in the industrial sector, including the IHP. Many different effects on the IHP TIS are visible. Although the focus on CO₂-reduction instead of energy-efficiency (F4) has created competition for the IHP from other technologies and thereby slightly undermines its legitimacy (F7), actors willing to work on the development and implementation of the IHP remain amply facilitated. Subsidies are available for the whole spectrum from pilot-project (F2) to demonstration (F1), and

market implementation (F5)⁵. Government organizations, sector organizations, consultants and research institutes frequently organize meetings and symposia (F3). They are also available for questions from industrial companies, often for free (F3). Although the IHP does not yet reach the required temperature levels for all industrial processes, the pay-back time for lower temperature processes is already around five years and companies with such processes are thereby by law obliged to implement them. This law is also increasingly being enforced (F5). Progress is also being made in research and development projects (F1/F2), making further temperature increase a matter of time. Still, in the Netherlands, only a handful of companies are active in IHP R&D projects or are implementing currently available IHPs. Companies involved on the supply-side are Dutch research institutes (e.g. ECN by TNO) and Dutch tailor-made technology suppliers, and on the demand-side the remaining Dutch-owned enterprises that have a strong footing in the engineering logic. As the following section will show, main barriers for IHP implementation come forth from increasing institutionalization of the capitalist logic on the demand-side of the innovation system.

4.3 The impact of the global regime on the Dutch TIS

The capitalist logic became increasingly institutionalized in the Netherlands as a result 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 the responses by Dutch actors. Appendix III provides an overview of exemplary quotes for these barriers to reflect their empirical foundation.

4.3.1 *Mimetic and normative pressures on Dutch firms*

In reaction to the increasing international competition, especially from Asian companies, Dutch conglomerates DSM and AkzoNobel divested their bulk chemical divisions. In their search for economic efficiency, they decided to focus on a few core areas with the highest margins. In these core areas, they subsequently strengthened their position through mergers & acquisitions, many of which abroad, thereby turning both companies into highly specialized companies that compete on market size in narrow market segments. This strategy change resulted from normative and mimetic pressures emanating from business schools teaching this strategy, using examples from successful (especially US) companies that had made such transitions earlier. Large consultancy firms like McKinsey also played a role in dispersing this strategy of focusing on core activities across the globe. In Dutch industrial clusters, this has led to the separation of previously integrated value chains and to the separation of utilities from the industrial companies. For instance, until 2002 all factories and research activities of the Chemelot industrial cluster were owned by DSM alone. Currently, more than 150 companies make up the Chemelot industrial cluster. 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 the IHP, the fragmented nature of industrial clusters creates important barriers. First of all, an IHP often connects industrial processes and these are now often owned by different companies. In addition, a heat pump not only touches core activities, but also non-core activities like maintenance and utilities, both of which are now generally outsourced. This results in coordination problems during the initiation of heat pump projects (F3). In addition, the now separated companies have created long-term contracts for the utilities they exchange. Due to these contracts, the financial benefits of an IHP often cannot be monetized since a reduction in heat production due to the IHP does not lead to reduced costs (F6). On most industrial parks, activities are organized to discuss energy efficiency and thus provide opportunities to overcoming the coordination barrier that impairs IHP diffusion.

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 that closes the gap between the payback time of CO₂-reduction measures and the five year payback time requirement.

However, an 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 take-overs by multinational owners

The non-core divisions sold off by Dutch process companies gained new owners, often international. Since these international headquarters have direct authority over their Dutch subsidiaries, and internationally the capitalist logic is dominant, this creates coercive pressures on the new Dutch subsidiaries – which constitute an important market segment for potential buyers of IHPs – to bring operations in line with the capitalist logic. Dutch subsidiaries are for instance instructed to further intensify the selling of non-core activities, thereby enlarging the earlier mentioned barriers related to the fragmented industrial clusters. They often also introduce a ‘lean’ company strategy - sometimes part of a ‘buy-squeeze-repeat’ strategy⁶, whereby all activities not necessary for the core processes are given up. This leads to the stop of R&D activities and external collaborations (F1) and to a discontinuation of collaboration networks where energy efficiency is discussed (F3). In general, the focus on core activities and ‘lean’ strategies means there is little interest for project evaluation or sharing of project results (F3) and companies do not participate in meetings or conferences where the more radical sustainable innovations like the IHP are discussed (F3). Process companies no longer have the knowledge in-house to implement a heat pump (F3) and they are often not familiar with the capabilities of technology suppliers (F3). In turn, technology suppliers do not know who in the process company to approach for selling their IHP (F5). All of this leads to a low demand for the IHP (F5).

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

Due to the pressures of international competition driven by cost and production volume, industrial companies were already reluctant to take risks in relation to their core processes. This reluctance is exacerbated after a take-over. Since 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).

Since the sustainability logic has remained in the periphery at the international level, environmental sustainability generally moves down in priority after a take-over (F4). For instance, from 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 take-over, energy efficiency investments are thus 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).

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

The above dynamics provide an explanation for why only a select group of, mostly Dutch owned, industrial companies show active interest in IHPs. These are the companies that experience no (or little) coercive pressure from their 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 the capitalist logic. For instance, when AkzoNobel rejected three unsolicited takeover proposals from the 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 in order 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 creating economic value on the short term to satisfy its shareholders which stood to gain a 30% profit share from the take-over. Even pension funds – typically considered long-term institutional owners – tend to be governed by daily stock value, as they have institutionalized reward systems around short-term profits. In an interview, the Unilever CEO indicated this coercive pressure is reinforced by normative pressures of the most influential management theory from the past 30 years that 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 result.

4.4 Response strategies of Dutch TIS actors to global regime pressures

Institutional pressures from the global regime are always mediated by local actors in particular ways. While 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. In the following, we discuss three illustrative response strategies from our empirical data.

4.3.1 Adaptation response

Remaining Dutch-owned companies are now highly aware of the coercive pressures that activist shareholders may place on a company. Since 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 push up stock-prices⁷ (F4). The reasoning usually is that as long as enough shareholder value is created, no far-reaching changes in the way the company is run will be demanded. As a result, also in Dutch-owned industrial companies, budgets, ROI and pay-back time criteria are increasingly strict (F6), leading to a low demand for IHPs (F5). What companies consider an acceptable payback-time currently decreases faster than what IHP performance increases can compensate. In this way, the adaptation response of process companies is exacerbating barriers for the diffusion of the IHP.

The historic focus of Dutch IHP suppliers to offer tailor-made solutions that achieve high-efficiencies and temperature conflicts with the dominant global regime logic. Risk reduction in operations in combination with a focus on cost competition has led process companies to demand proven, cheap, standardized, and modular solutions that meet the strict investment criteria. Many companies thus prefer large international technology suppliers who offer such solutions – although

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 (Barton et al., 2017).

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 at emulating the logic of cutting costs through standardization and modularization (F2). Via this isomorphic behavior they aim to connect with the global value chain.

4.3.2 Persuasion response

A take-over of a Dutch industrial company division by an international headquarter 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 up payback time criteria for energy efficiency measures (F7). They also spread the argument that allowing pilot-projects in Dutch factories may, when successful, lead to opportunities for subsequent distribution to other factories world-wide. These discussions are, however, as one interviewee called it, 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 the sustainability logic. It is for instance pushing for more stringent CO₂-reduction goals and implementation strategies at EU-level and within UN climate talks. In addition, it is trying to persuade other Western European countries to also implement an additional CO₂-tax with the purpose of maintaining 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 institutionalization of the sustainability logic internationally.

4.3.3 Authoritative response

In response to the takeover battle around AkzoNobel, the subject of unsolicited takeovers has attracted the attention of policy makers. 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 to respond appropriately. Members of Dutch parliament have also called for a preventive government test in the event of an unsolicited bid on Dutch companies that are a.o. vital for the Dutch economy and employment. The association for institutional investors opposing such protectionist policy, argues in line with the Capitalist logic, saying it would make Dutch stock-listed companies lazy, as they will no longer feel the competitive pressures of the market. Although such measures may prevent further institutionalization of the capitalist logic within Dutch industrial companies, and thus limit further creation of barriers for the implementation of IHPs, they still remain to be taken.

5. Discussion and conclusion

This paper set out to study the impact of a global regime on radical innovations that are developed and diffused within a Technological Innovation System. For this purpose, we studied the case of the global processing industry and the impact of its regime on the TIS of the industrial heat pump. Our case study shows that the rapid institutionalization of a new logic can outpace the rate of technological development of the 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, that the acceptable payback time as maintained by potential buyers decreased faster than technological improvements could compensate for, effectively making the innovation *less* attractive over time.

The case study shows that coercive, normative and mimetic pressures reproduce characteristics of the global regime at local level, resulting in barriers to the development and particularly the adoption of radical innovations that do not align with the dominant regime logic. These dynamics are summarized in the below Table 5.1.

Characteristics of 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	<p><i>Coercive:</i></p> <ul style="list-style-type: none"> - Shareholders coerce this strategy on corporate management <p><i>Normative:</i></p> <ul style="list-style-type: none"> - Business schools teach this strategy - Competition, driven by cost and production volume, reinforce this <p><i>Mimetic:</i></p> <ul style="list-style-type: none"> - Consultancies recommend this strategy - Firms successful with this strategy are emphasized 	<p>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. They take risk on the commercial side and reduce risk in operations, restraining innovation in core processes. They focus on cheap, standardized and modal solutions, which the IHP is not. However, Dutch IHP suppliers started to mimic the standardization approach to IHP.</p> <p><i>System functions most strongly impaired:</i> guidance of the search, mobilization of resources and knowledge diffusion all feed into weak market formation</p>
Corporate strategies focus on short term economic valuation and give no priority to sustainability	<p><i>Coercive:</i></p> <ul style="list-style-type: none"> - Coercive pressure on subsidiary from multinational owner - Shareholders coerce this strategy on corporate management <p><i>Normative:</i></p> <ul style="list-style-type: none"> - Financial analysts focus on short-term economic valuation, resulting in pressure from stock market 	<p>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 impair other system functions for innovations that do not meet strict investment criteria – particularly for sustainable innovations which are no longer strategically preferred.</p> <p><i>System functions most strongly impaired:</i> guidance of the search and mobilization of resources feed into weak market formation</p>
Laissez-faire policy focused on incentivizing sustainable innovation instead of forcing it	<p>Coercive-normative:</p> <ul style="list-style-type: none"> - Powerful industrial lobby for level-playing field in globally competitive industry 	<p>There is very limited policy support and no enforcement for sustainable innovations.</p> <p><i>System functions most strongly impaired:</i> guidance of the search and mobilization of resources feed into weak market formation</p>

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

Our findings show that many barriers induced by the global regime hold not only for the IHP, but for most sustainable industrial innovations that move beyond incremental industrial process improvements. Cutting human and financial innovation resources and maintaining strict investment criteria affect sustainable industrial innovations in general, whereas separation of value chains and the ensuing coordination problems hold specifically for innovations that link different segments of the value chain, like the IHP. Fruitful venues for further research include studying how coercive, normative

and mimetic pressures affect the interactions between global regimes and local TIS in other sectors and for other types of innovation, to uncover more interaction patterns and understand the prevalence of these patterns. Comparative analyses between cases in which emerging TIS are in line with the global regime logics and in which they are not, will help shed more light on the positive and negative impacts of global regimes on emerging TIS.

5.1 Implications for TIS actors' response strategies

Our case study also illustrated a set of strategies by which TIS-actors responded to the global regime pressures. Most notable is the adaptation strategy of Dutch IHP producers to mimic the standardization approach to gain access to 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" (Fuenfschilling & Binz, 2018, p.738). Although this isomorphic behavior increases the Dutch producers' chances to tap into a global market, it also opens up their niche position to the competition of more powerful, preferred, global suppliers. The question is whether the 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 protect these corporations from hostile takeovers. There are over 10.000 benefit corporations, like Ben & Jerry's. Such policies, to protect companies in deviating from the global regime logic, differ widely per country and could be implemented more widely and homogeneously to indirectly enable and protect firms that aim to solve societal challenges that are typically not in line with the capitalist logic.

Other response strategies are aimed more directly at pressuring the regime to change. They involve normative pressures from local subsidiaries to persuade their global owners to prioritize sustainable innovation. They also involve coercive pressures from activist shareholders, aimed at institutionalization of the sustainability logic. For instance, 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, organizations like 'As You Sow' make use of their shareholder power to pressure companies in a wide range of sectors to reduce CO₂-emissions. Although not yet visible in the Dutch industrial sector, activist shareholders could play a role in further institutionalizing the sustainability logic within the Dutch industrial sector, and possibly beyond.

Although these response strategies by TIS and other actors have potential, they have, to date, shown little impact – thus reflecting the powerful pressures from the global regime. Further research should look into identifying response strategies that may negate these regime pressures more effectively. However, there is also indication of a potential logics change from within the regime. In August 2019, the CEO's 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" (Roundtable, 2019). Gartenberg and Serafeim (2019) argue that this is interpreted as a rebuke of Milton Friedman's famous 1970 essay, 'The Social Responsibility Of Business Is to Increase Its Profits,' that "helped launch a half century of 'shareholder capitalism'" (p.1).

The powerful pressure a global regime can exert on a local, emerging TIS and its radical innovation leads to a final observation. While many transition studies highlight the role of national governments in steering and facilitating socio-technical and innovation system developments, this case study shows that the global regime puts strong limits to what a country can achieve. Not only firms are 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 around a 'level playing field' and 'carbon leakage' and the fact that firms are increasingly foreign-owned.

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Appendix I: Institutional logics of societal sectors (adapted from Thornton et al. 2012)

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	<p>“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 characterised 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 organised large-scale corporations [...].” (Homburg et al., 1998, p.1)</p> <p>“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.” (Aftalion, 2001, p.168)</p> <p>“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.” (Aftalion, 2001, p330)</p> <p>“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 (Pavitt, 1984, Walsh, 1984).” (Bauer and Fuenfschilling, 2019, p?)</p>
Sustainability logic	<p>“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.” (Government official)</p> <p>“The parent company starts to ask questions because they want to be included in the Dow Sustainability Index.” (industrial company)</p> <p>“The director considers sustainability important but no company-wide goals have been set. [...]” (subsidiary of international conglomerate)</p> <p>“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.” (Homburg et al. 1998, p5)</p> <p>“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.” (Bauer and Fuenfschilling, 2019)</p>
Capitalist logic	<p>“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’. (Aftalion, 2001, p404)</p> <p>“If we talk in ‘euros’ then management is happy.” (subsidiary of international industrial company)</p>

	<p>“[...] the growing influence of financial analysts on the behavior of 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.” (Aftalion, 2001, p331-332)</p> <p>“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.” (Professor Energy, Resources & Technological change)</p> <p>“If you set up your plant here, you can fully focus on your core business. There is a wide range of service and utilities, etc. available to cover all your operating activities, with an excellent price, quality ratio.” (industrial cluster)</p>
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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	<ul style="list-style-type: none"> “Many companies do not want to be a testing ground, so you have to look for demonstration opportunities.” (engineering firm)
F1 / F2 / F3	innovation projects and external collaborations are halted after divisions of Dutch industrial companies are taken over	<ul style="list-style-type: none"> “In the past we were [involved in external collaborations or innovation projects], under [Dutch industrial company], but now [under private equity firm] less. Projects with external partners were carried out within the [Dutch industrial company].” (former division of Dutch industrial company now partially owned by private equity firm)
F2	Dutch IHP suppliers’ innovation efforts are thus increasingly aimed at emulating the rationality of cutting costs through standardization and modularization (F2).	<ul style="list-style-type: none"> “Technology suppliers must (from client) offer cheap and then come up with standard solutions.” (consultants) “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.” (Dutch heat pump supplier #2)
F3	Coordination problems	<ul style="list-style-type: none"> “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.” (former division of Dutch industrial company now owned by international conglomerate)
	Low involvement of companies within discussion platforms for energy efficiency.	<ul style="list-style-type: none"> “[...] there has never been a meeting [on energy management in the cluster] where everyone involved was present.” (industrial company partially owned by private equity firm)
	Companies do not come to meetings or conferences where the IHP is discussed.	<ul style="list-style-type: none"> “There is limited knowledge exchange between parties in the region.” (former division of Dutch industrial company now owned by international conglomerate)
	After take-overs, companies do not continue internal networks discussing energy efficiency.	<ul style="list-style-type: none"> “Within DSM there was a platform for energy. That has disappeared in the current conglomerate. Replacing it would be welcome.” (industrial company partially owned by private equity firm)
	Little time for evaluation and sharing of project results	<ul style="list-style-type: none"> “Often, after a project ends, there is little interest in evaluation, even though experiences may be very important for sister companies (and suppliers).” (consultancy report)
	Industrial companies are not familiar with the capabilities of technology suppliers	<ul style="list-style-type: none"> “Engineers and operators do not understand what a heat pump does.” (Dutch industrial company) “Most firms are not aware of the technical possibilities of waste heat utilization.” (Dutch Heat Pumping Journal, issue 217, p36)
	Companies do not have the knowledge in-house to implement a heat pump (F3)	<ul style="list-style-type: none"> “We have no idea how to electrify our process.” (Dutch subsidiary of international conglomerate, former division of Dutch company)
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.	<ul style="list-style-type: none"> “One and a half year 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]." (former division of Dutch industrial company now partially owned by private equity firm)
	Dutch subsidiaries need permission for investment decisions from their international headquarter.	<ul style="list-style-type: none"> "[industry] is for investments dependent on mostly foreign owners." (sector association).
	Environmental sustainability moves down on the priority list after a take-over.	<ul style="list-style-type: none"> "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]." (former division of Dutch industrial company now partially owned by private equity firm)
	Since 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 push up stock-prices.	<ul style="list-style-type: none"> "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." (Dutch company).
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).	<ul style="list-style-type: none"> "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, it is not there now." (engineering firm)
	Low demand for heat pumps	<ul style="list-style-type: none"> "Engineering firms are also not able to actually sell the technology." (technology supplier)
	Low demand for technologies that touch the core process.	<ul style="list-style-type: none"> "Companies all say: do not touch my process." (consultant) "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." (engineering firm)
	IHP suppliers no longer know who to approach in the Dutch subsidiary factory to sell their IHP.	<ul style="list-style-type: none"> "Suppliers usually do not know whom to turn to in the process industry. It is certainly not the purchasing department." (network organization)
	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).	<ul style="list-style-type: none"> "[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." (Dutch heat pump supplier)

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'.	<ul style="list-style-type: none"> • "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." (Engineering firm)
	The financial benefits of an IHP often cannot be monetized	<ul style="list-style-type: none"> • "Yes, there are always 'marriages' in the energy supply between industrial companies in which changes occur along the way: between partners, with the children etcetera. 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." (sector association)
	<p>After a take-over, budgets are often tightened and strict ROI, and pay-back time criteria are dictated by the investors or parent company that the IHP does not satisfy (F6)</p> <p>It is not uncommon that only investments with a pay-back time below two years are funded, even though energy efficiency projects with a pay-back time of less than five year are obligatory by Dutch law (F6).</p>	<ul style="list-style-type: none"> • "[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." (Dutch subsidiary of large international conglomerate, former division of Dutch company)
	In Dutch-owned industrial companies as well, budgets, ROI and pay-back time criteria become increasingly strict (F6)	<ul style="list-style-type: none"> • "In general, there is a lot of pressure on investment decisions – the accepted payback time is getting shorter and shorter." (Dutch company)
F7	Dutch subsidiaries to lobby at the international headquarters stretching up payback time criteria for energy efficiency measures.	<ul style="list-style-type: none"> • "Discussions about stretching up payback time criteria are interesting but also tough conversations." (Dutch subsidiary of international conglomerate, former division of Dutch company)