

High Value Manufacturing: Capability, Appropriation, and Governance

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Abstract

Manufacturing competitiveness is on many policy agendas, born out of a concern for firms in high-cost economies finding themselves outcompeted by low-cost rivals. Government policy makers and manufacturing firm strategists have put their faith in what we label as high value manufacturing (HVM). We see HVM as an incipient phenomenon currently in a situation of prescience, as something that is still “in-the-making,” with manufacturing firms trying to find ways to be able to step away from having to compete on price. This paper consults relevant strategy theories with the purpose to pinpoint the issues and problems that need to be accommodated for bringing HVM into being and for creating the effects that are anticipated. We found that HVM must be seen as a distributed activity, thus realizing complex functionality for a system-of-use, while being subjected to path constitution. For HVM to function, the firms involved need to find solutions to the capability problem, the appropriation problem, and the governance problem. We suggest that further research needs to involve itself in problem-solving activity to assist in bringing HVM about while simultaneously further developing strategy theory geared toward firms that are involved in a distributed activity like HVM.

Key words: Manufacturing competitiveness, high value manufacturing, strategy, operations, supply chains, innovation, path constitution

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Introduction

The competitiveness of manufacturing firms in high-cost economies is a concern as a consequence of increasing global competition, specifically that from low-cost economies (BMBF, 2006; EC, 2013; Porter & Ketels, 2003). Competitiveness of manufacturing firms appears on policy agendas in France (“La Nouvelle France Industrielle”), Germany (Industrie 4.0), Japan (the “Rebirth of Japan” strategy), South Korea (Manufacturing 3.0), the UK (“high value manufacturing” (HVM) catapults), Europe (the EU “Factories of the Future” initiative), and the USA (the “advanced manufacturing partnership”). Ironically, emerging economies like China (the “Made in China 2025” plan) and India (the “Make in India” initiative) take similar actions. There is variety in terminology but convergence in concern centered on the urge to step away from relentless competition on price. For the purpose of this paper, we stick with the term HVM to refer to the resolution for manufacturing firms to avoid price competition.

HVM terminology has taken its place within policy and management speak. While manufacturing competitiveness has gained much exposure, it has seen increased obfuscation, as any resolution by which manufacturing firms avoid being sucked into price competition is seen as HVM. For some, HVM is seen as adopting solutions like “servitization” (Baines, Lightfoot, Benedettini, & Kay, 2009; EC, 2010a; Martinez, Neely, Ren, & Smart, 2008) or the “Internet of things” and the integration of logistical and manufacturing processes by organizing data

flows in real-time fashion across fast distances, dubbed “Industry 4.0” (BMBF, 2012; BMWi, 2015a; EC, 2011; Kagermann, Wahlster, & Helbig, 2013). Others take a more encompassing approach by emphasizing the need for continuous innovation and the development of advanced manufacturing technology to increase competitiveness and to deliver on sustainability, a low carbon future, and wider corporate social responsibility issues (BMBF, 2006; EC, 2013; Edwards, Battisti, & Neely, 2004; Hauser, 2010, 2014; IfM, 2016; Sainsbury, 2007; TSB, 2012). There are those who equate HVM to specific “high-tech” sectors (BMBF, 2017; Dunkerton & Bustard, 2013; EC, 2011; TSB, 2012). There is much hope invested in HVM (BMBF, 2012; EC, 2013; Foresight, 2013; TSB, 2012), but the extent to which and in what way HVM is manifested is still unclear. Is it a government policy or a company strategy? Is it a policy to entice firms to adopt HVM as a strategy? Is it empty rhetoric or is HVM actually appearing in some shape or form?

We consider HVM to be an incipient phenomenon. We have found that descriptions of what HVM could be or should be oversimplify, often highlighting a single mechanism such as differentiation, servitization, digitization, business model innovation, dynamic capability, or the deployment of advanced manufacturing technology, with each featuring extensive literature. Although each mechanism has extensive academic literature attached, academic writing on HVM as an overarching concept is sparse (MacBryde, Paton, & Clegg, 2013). HVM initiatives are attempts by policy makers and firms to solve the problem of manufacturing competitiveness. Through these activities, they generate HVM and consequently learn if and how practicing HVM realizes the outcome it is supposed

to achieve. This process of giving HVM shape and form is currently taking place, hence its status as an incipient phenomenon.

For this reason, we propose a literature review that takes the form of a theory consultation. Taking clues from carefully selected HVM policy papers, we critically reflect on the applicability for HVM of the theoretical insights they – often implicitly – employ. By surveying underlying theories, we identify areas of contention. By introducing an additional theory, we enhance HVM practitioners’ understanding of what they are dealing with and also propose a research agenda by which both the HVM phenomenon and theory can be developed. This exercise then allows us to problematize HVM and pinpoint the specific issues that need to be the focus of HVM research. It also indicates to HVM practitioners what they need to concentrate on to fulfill the promise of avoiding competition on price.

We proceed by first explaining how we carried out the literature consultation. We then continue with the consultation proper, looking at relevant theory from the strategy field. This is all in pursuit of a more informed problematization of the HVM phenomenon (Alvesson & Sandberg, 2011). We conclude by using this problematization to suggest further research that we hope will help bring HVM into being and also develop strategy theory for firms engaged in a distributed activity like HVM.

Consulting theory for an incipient phenomenon

Traditionally, methods for conducting a literature review anticipate that a topic is mature enough to have a sufficient volume of work published so that a review is both possible and warranted. Because HVM is an incipient phenomenon, a body of literature on the subject area cannot be expected to exist. HVM is still “in-the-

making.” This is the cause for adopting a literature review style, which we describe as a “theory consultation.”

Phenomena are occurrences that attract interest when they are associated with a problem, especially if a phenomenon as well as the problem is ill understood (von Krogh, Rossi-Lamastra, & Haefliger, 2012). Most scholarly endeavors in management research focus on theory rather than phenomena and their underlying problems (Hambrick, 2007; Schwarz & Stensaker, 2014), as contributions to the field are expected to be contributions to theory (Corley & Gioia, 2011). Schwarz and Stensaker (2014) argue that theory-driven research is losing sight of the phenomenon that was the object of inquiry in the first place and, therefore, often impedes the development of new theory. Phenomenon-driven research seeks to make sense of management practitioners’ situations to help resolve the associated problems. A literature review in aid of phenomenon-based research would be multitheory, as it seeks to bring a multitude of existing insights to bear upon the situation, not necessarily to solve the associated problem but at least to pinpoint what the problem is about and hence facilitate further research.

Many theoretical constructs that are now taken for granted originally appeared as a consequence of management practitioners dealing with problematic situations. Chandler (1962, 1977), for instance, captured this in his seminal work on strategy and organizational structures. He discovered that the multidivisional structure was a solution that had emerged to deal with the problem of how to manage a multibusiness firm, as firms had branched out across many different activities from the beginning of the 20th century onwards. HVM is another one. Because HVM is emerging while the problem of manufacturing competitiveness is being dealt with, an inductive approach (Eisenhardt, 1989)

would not be suitable, as there is, as yet, little to investigate empirically. We are in a situation of prescience, where the way forward is to “develop an orientation toward prospection” (Corley & Gioia, 2011, p. 25). It is especially in a situation of prescience that research aims to understand the phenomenon first (Schwarz & Stensaker, 2014; von Krogh et al., 2012), that a consultation of multiple existing theories that are deemed relevant would be the appropriate approach in aid of further specifying the difficulties that entangle the incipient phenomenon to direct the research effort (Pettigrew & Fenton, 2000; Pettigrew & Whipp, 1991).

Our approach to conducting our theory consultation needs to be systematic. We need to decide which strategy theories to consult and what we need to bring to bear upon HVM. Cues need to be taken from the arena where the problem is being raised. In this case, these are policy papers that address the problem of manufacturing competitiveness. Consequently, our theory consultation consisted of three steps.

First, we scrutinized policy papers of the UK government, the German government, and the European Commission (EU). We decided to take two leading industrial nations with contrasting approaches to economic policy. German policy making orientates itself more to corporatism, while British policy making is informed more by *laissez faire*. The EU was added because European policy informed the UK government as well as the German government.

For the UK, we went back to 2003, with Porter and Ketels (2003) commissioned by the then Department of Trade and Industry. The UK government went through a number of reorganizations with manufacturing competitiveness falling under the Department for Business, Innovation & Skills, which was recently replaced by the Department for Business, Energy & Industrial Strategy, with

various government policy units and agencies like the Technology Strategy Board and Innovate UK appearing and disappearing, while adding policy considerations.

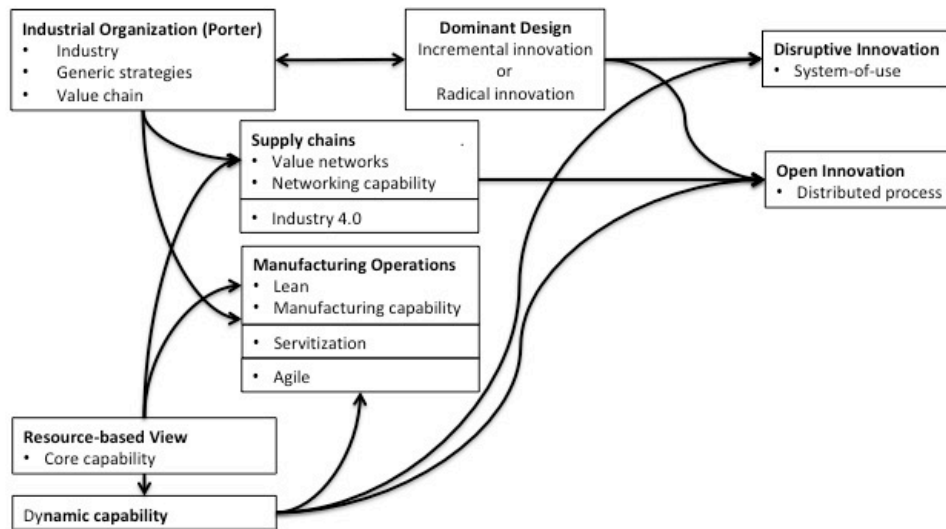
In Germany, we found that responsibility for manufacturing competitiveness was mostly shared between the Bundesministerium für Bildung und Forschung (BMBF) and the Bundesministerium für Wirtschaft und Energie (BMWi), who created initiatives by which manufacturing competitiveness was addressed. We traced HVM back to Germany's high-tech strategy (BMBF, 2006).

With regard to Europe, the EU and the Directorate-General for Research and Innovation are leading on the EU's Factories of the Future initiative. This is a flagship program, launched in 2008 as part of the European Economic Recovery Plan (EC, 2010a).

We scrutinized a total of 43 reports and policy papers for references to manufacturing competitiveness and HVM (see Appendix 1). We abstracted all these documents to capture the essence of their argumentations for us to match these with the existing strategy theory. We found authors of policy papers very rarely refer directly to academic literature, but we were able to recognize strands of strategy theories in their writings.

As our second step, we traced the snippets of theory back to their original sources. Figure 1 provides an overview of the theoretical approaches that we detected in the policy argumentations. We proceeded to critically compare and contrast the core theoretical arguments to then add additional insights to prepare for the third step of identifying key issues that need to be addressed for HVM to come into being.

Figure 1: Strategy Theory Traces in HVM Policy



The industrial organization approach

The argument that manufacturing firms who find themselves unable to compete on costs are then obliged to compete on value is straight from Porter (1980, 1985). In the UK, it was the Porter and Ketels (2003) report, based on the Porter (1990) diamond model, that made this point (Birdi, Denyer, Munir, Neely, & Pradhu, 2003). Although addressing the UK economy as a whole, manufacturing was singled out as especially lagging behind. In Germany, the same argument is present in the government’s high-tech strategy (BMBF, 2006, 2010), as is in the EU’s Factories of the Future initiative (EC, 2010a, 2013).

Porter’s (1981) logic is derived from industrial organization economics. Firms are seen as competing in an industry. An industry is a value system producing a product or a service, which commands a price depending on what end-users are prepared to pay. The final sales price and how much of the margin

is appropriated by each firm in the value system then determine the performance of a firm. Whether a manufacturing firm is able to add value to a product or service relative to rival firms, suppliers, buyers, substitutes, and potential entrants indicates the strategic position a firm. Kotha and Orne (1989) developed generic manufacturing strategies that fit with Porter's (1980) generic strategies. If a manufacturer is denied the opportunity to be the low-cost producer, the alternative is to have a value chain that can deliver on opportunities for differentiation or focus on the basis of added value.

Servitization as an HVM solution is a specific form of differentiation. The tendency has been for manufacturing firms to view services as a necessary evil useful only in the context of marketing ploys (Wise & Baumgartner, 1999), with end-user value considered to reside in the physical good and the service component merely an add-on (Gebauer & Friedli, 2005). Vandermerwe and Rada (1988) coined the term servitization to describe how firms moved from offering goods with some maintenance, support, and financing added to offering "bundles" consisting of customer-focused combinations of goods, services, and knowledge.

Manufacturing firms pursuing a differentiation by servitization strategy offer tailored solutions to their customers, even if this requires the incorporation of products from other vendors (Baines et al., 2009; Davies, 2004; Miller, Hope, Eisenstat, Foote, & Galbraith, 2002). The servitization observed within manufacturing firms is picked up by some advocates of HVM as the way in which "high value" is to be achieved (Baines et al., 2009; MacBryde et al., 2013; Martinez et al., 2008) or to be at least part of HVM activity (EFFRA, 2016; Livesey, 2006; TSB, 2008). The extent to which a manufacturing firm is pursuing a servitization strategy is expressed in terms of the product-service continuum (Gebauer &

Friedli, 2005; Neu & Brown, 2005; Oliva & Kallenberg, 2003). The continuum stretches from traditional manufacturing, with services offered as an add-on, to tangible products, through to full service provision, where the services are the main part of the value proposition (MacBryde et al., 2013).

However, servitization requires two profound changes in how a manufacturing firm operates (Oliva & Kallenberg, 2003). First, the focus has to shift from ensuring the proper functioning of the product to pursuing efficiency and effectiveness of the customer's processes related to using the product. Second, the way the customer is dealt with has to shift from a transaction-based focus on selling products to a relationship-based focus on repeated and organized interactions. Servitization is considered a way for manufacturing firms to escape price competition and commoditization, especially when product quality and technological superiority become less of a differentiator (Coyne, 1989; Frambach, Wels-Lips, & Gündlach, 1997; Gebauer & Fleisch, 2005).

In a different development, Porter's value chain construct gained prominence in supply chain management (SCM), especially after Raedels (1995) introduced the phrase "value-focused supply management." It is also well recognized in HVM policy papers that external supplies are increasingly intertwined with internal operations (e.g., BMBF, 2012; BMWi, 2015a; EFFRA, 2016; Sainsbury, 2007; TSB, 2008). In contrast to Porter (1980, 1985), SCM emphasizes cooperation rather than competition. Firms should promote overall value creation through cooperation in the supply network over that of value capture and appropriation within the network (Kim & Mauborgne, 1997; Lamming, 2000; Lamming, Johnsen, Zheng, & Harland, 2000). Nevertheless, Cox, Watson, Lonsdale, and Sanderson (2004) argue that the purpose of supply

network strategy is value appropriation by more capable firms, which are controlling critical assets, at the expense of less capable firms. As with competition, cooperation still means that firm-level strategy is about positioning a firm but now in the supply network (Noke & Hughes, 2010; Peppard & Rylander, 2006). Firms within supply networks are increasingly looking to upgrade their value propositions to reposition themselves to appropriate more value (Edwards et al., 2004; Noke & Hughes, 2010).

From this point, value became understood as having two aspects: “tangible value” or the end-user value, as put forward by Porter (1980), and “intangible value” or the value of the relationship between buyers and suppliers (Cox, 2004). Adding supply chain considerations, therefore, refocused concerns on the combined network of firms constituting the entire conversion process, thus leading to the recognition that competition increasingly takes place on the basis of “supply network versus supply network” rather than “firm versus firm” (Shi & Yu, 2013). In supply networks that emphasize high end-user value, competitiveness facilitated by speed, quality, flexibility, and cost efficiency are prioritized over the simpler consideration of transaction costs (Morrow, Sirmon, Hitt, & Holcomb, 2007). HVM policy documents indeed recognize the networked and distributed nature of manufacturing (Birdi et al., 2003; EC, 2014; Livesey, 2006; Martinez et al., 2008; Sainsbury, 2007; TSB, 2008), with those advocating Industry 4.0 seeing it as HVM’s most essential feature (BMBF, 2012; BMWi, 2015a; EFFRA, 2016).

The term “Industry 4.0” was first used at the 2011 Hanover, Germany, Fair (Draht & Horch, 2014; Schneider, 2018). It signifies the fourth industrial revolution on the basis of increased connectivity as a consequence of the “Internet

of Things” (Kagermann et al., 2013). This connectivity, also labeled as the “cyber-physical system,” allows for real-time information flows between products, production processes, and logistical systems during the development, manufacturing, transport, delivery, and usage of product/service bundles. It draws on the capabilities that are imagined to exist as a consequence of combining (additive) manufacturing, logistics, sensor technology, the Internet, cloud computing, and big data. Most efforts currently are put into making the various technologies work in unison and to find concrete applications (BMW, 2016a; Liao, Deschamps, de Freitas Rocha Loures, & Pierin Ramos, 2017), but once it is made to work, Industry 4.0 is expected to transform the way in which businesses cooperate (Brettel, Friedrichsen, Keller, & Rosenberg, 2014; Monostori, 2014; Schneider, 2018).

Interestingly, servitization and the networked approach to manufacturing led to criticism in HVM quarters about the appropriateness of the industry and, therefore, industrial organization and Porter’s approach as the starting point for the analysis. Livesey (2006) points out that the product–service bundles that form HVM output do not neatly fit the product and service categorizations by which industries are defined. A product–service bundle combines manufactured goods with services, support, and knowledge provided by a range of different firms that may not necessarily belong to the same industry (Vandermerwe & Rada, 1988).

The resource-based view

The resource-based view would advise manufacturing firms to find their competitive advantage in their valuable, rare, inimitable, and nonsubstitutable capabilities (Barney, 1986, 1991). Indeed, manufacturing capability has itself been

recognized as a source of competitive advantage (Brown & Blackmon, 2005; Hayes & Pisano, 1996; Schroeder, Bates, & Junttila, 2002). The resource-based view adds an additional layer of understanding to the Industrial Organization approach in that a manufacturing firm's competitive advantage becomes sustainable if it is based on core capabilities that are unique to the firm (Amit & Schoemaker, 1993; Barney, 1986). Furthermore, the extent to which a core capability is essential for the total package that is offered to the market determines how much of the final sales price is appropriated by this firm (Coff, 2010).

The more popular approaches with regard to manufacturing capability advocate cost-based efficiency with methodologies such as "Lean" (Womack & Jones, 2003; Womack, Jones, & Roos, 1990). In contrast, some HVM policy documents suggest that capabilities of a manufacturing firm should extend beyond manufacturing to also include product design, customization, branding, information and communication technology, or rapid delivery (e.g., BMBF, 2012; GT&I, 2014; Livesey, 2006; Martinez et al., 2008; TSB, 2008). Many documents also point at the essential role of human resources in manufacturing firm capabilities, especially if a firm is to move into HVM (e.g., BMWi, 2016b; Sainsbury, 2007; TSB, 2012).

Adopting the logic of the resource-based view, the capabilities needed for servitization are expected to be the basis of sustainable competitive advantage (Auramo & Ala-Risku, 2005; Gebauer & Friedli, 2005; Mathieu, 2001; Oliva & Kallenberg, 2003) and to allow for the appropriation of a bigger and more stable share of the overall margin (Brax, 2005; Mallaret, 2006; Wise & Baumgartner, 1999), especially when the customer becomes increasingly dependent on the firm (Corrêa, Ellram, Scavarda, & Cooper, 2007; Vandermerwe & Rada, 1988). This

shift toward product–service bundles has clearly informed HVM policy makers, as they notice the merits of a more comprehensive offering and also recognize the link to the service economy and its association with knowledge-intensive work. Additionally, adopting the resource-based view logic, the concept of “best value supply networks” is emerging as a core capability (Boyer & Hult, 2005; Ketchen Jr & Hult, 2007) pertaining to the supply network as a whole as it competes with other supply networks.

The resource-based view, such as the industrial organization approach, is a rather static representation, which assumes both the value system and firm capabilities as a given. These strategy theories do not address how competitive advantage develops with time (Lockett, Thompson, & Morgenstern, 2009; Shanley & Peteraf, 2006). This is a criticism that Porter (1991) himself has admitted to. Porter (1980) recognized that industries are subjected to lifecycles, as did Helfat and Peteraf (2003) for capabilities. On the basis of this specific conceptualization of change, there is an expectation that a value system becomes prone to price competition as it matures while simultaneously opening up opportunities for differentiation and focus as demand becomes more sophisticated. Nevertheless, this is bound up with the prospect that eventually price will become the ultimate competitive tool, even within more differentiated strategic groups and market niches. The bigger questions of how value systems emerge, change, and disappear, what active role a firm can have in this process, and whether manufacturing firms can avoid eventually being sucked into price competition is not addressed. These bigger questions are particularly pertinent for HVM as an incipient phenomenon because for it to come into being, it requires development and change.

Dynamic capability

Within the strategy realm, the ability to change has been coined as dynamic capability (Helfat et al., 2007; Teece, Pisano, & Shuen, 1997). In a way, dynamic capability builds on the resource-based view in that the resource base is responsible for firm performance. Yet, dynamic capability departs from the resource-based view, as the emphasis is put on the ability to accumulate, develop, and renew the resource base in the face of new demands and changing environments (Dierickx & Cool, 1989; Makadok, 2001; Winter, 2003). Consequently, some writers (O'Reilly III & Tushman, 2004; Raisch, Birkinshaw, Probst, & Tushman, 2009) suggest firms should be ambidextrous, thus aiming to exploit their existing core capabilities while simultaneously displaying dynamic capability by searching for their next generation of core capabilities (March, 1991).

The notions of core capability and dynamic capability were already present in the Hayes and Wheelwright (1984) framework that characterizes a firm's manufacturing operations against a ladder of four abilities (increasing from internally neutral to externally neutral to internally supportive and finally to externally supportive). The third internally supportive stage in effect sees manufacturing as a core capability that underpins a manufacturing firm's competitive strategy while, in anticipation of later work on dynamic capability, the fourth externally supportive phase sees firms actively foreseeing and developing new manufacturing capabilities.

More recently and pre-empting the HVM debates, the accepted focus on the pursuit of efficiency through "Lean" was challenged by the increasing need for manufacturing flexibility and versatility. This inspired the development of "Agile"

methodologies (Jin-Hai, Anderson, & Harrison, 2003) that, while continuing to acknowledge the importance of efficiency and quality, also recognized the increasingly unpredictable and changing environment that manufacturers faced. “Agile” is primarily concerned with ensuring success in a volatile environment and emphasizes the importance of the manufacturer’s ability to adapt to change and variability by utilizing the latest technology and capitalizing on the knowledge base of the organization. “Agile” is put forward as basic manufacturing capability of HVM firms in combination with “Lean,” effectively claiming that manufacturing firms should be ambidextrous (e.g., BMWi, 2016a; EC, 2014; EFFRA, 2016; GT&I, 2014; TSB, 2008).

HVM policy papers mention innovation rather than dynamic capability as the means by which manufacturing firms can escape eventual price competition and create new value propositions, but the argument is the same (e.g. Birdi et al., 2003; BMBF, 2006, 2010, 2012, 2017; BMWi, 2015a, 2015b; EC, 2011, 2013; GT&I, 2014; Hauser, 2010, 2014; IfM, 2016; Martinez et al., 2008; Porter & Ketels, 2003; Sainsbury, 2007; TSB, 2008, 2012). Interestingly, people working on dynamic capability look at the innovation literature for further inspiration (Easterby-Smith, Lyles, & Peteraf, 2009), while people in innovation use dynamic capability to elaborate innovation (Lawson & Samson, 2001; Lichtenthaler & Lichtenthaler, 2009).

Innovation and its connections with strategy

Porter’s (1980) idea of industry life cycles mirrors Utterback and Abernathy (1975), who link innovation activity of a firm to the product lifecycle, expecting product innovation to be prevalent during the earlier stages, when firms and end-

users are getting to grips with the product that is on offer. Halfway through, both product and production process settle on a dominant design that defines the relevant features of the product as well as the end-user value these represent. Process innovation is associated with the latter stages, as the product and the production process become standardized, with competitive advantage mostly realized as a consequence of efficiency gains through improved production facilities. Like Porter (1980), they argue that by then price competition has become inevitable. The only way to escape it is to instigate a new life cycle.

Basing innovation on the product lifecycle allows for the distinction between incremental innovation, which occurs while the life cycle is playing out, and radical innovation, which involves the start of a new lifecycle (Abernathy & Utterback, 1978; Suárez & Utterback, 1995; Utterback & Suárez, 1993). This sequence of evolution and revolution is further elaborated in terms of punctuated equilibriums (Anderson & Tushman, 1990; Tushman & Anderson, 1986). Incremental innovation refines and improves, while radical innovation destroys and makes obsolete (Abernathy & Clark, 1985), leading to business model innovation. As price competition is the inevitable consequence of a product lifecycle, it is only through continuous business model innovation that manufacturing firms may be able to escape.

Christensen's (1997) re-conceptualization of business model innovation as disruptive innovation has been picked up as a requirement for HVM (e.g., BMWi, 2015a; BMWi, 2015b; EPSI, 2011; Foresight, 2013; Hauser, 2014; HMGovernment, 2017; Prognos, 2016). Christensen (1997) distinguishes between disruptive and sustaining innovation. Sustaining innovation improves the performance of existing offerings. Disruptive innovation paradoxically, initially, creates products

that underperform in the eyes of existing customers but appeal to new customers because they allow for product features that are not part of the existing offering. This is paired with the presumed tendency of sustaining innovation to generate improvements that eventually exceed the needs of many existing end-users who are then willing to scale-down to the lower performing, cheaper options offered as a consequence of disruptive innovation.

Christensen (1997) and Abernathy and Clark (1985) differ with regard to the underlying process model, with Abernathy and Clark referring to life cycles while Christensen elaborates the process in terms of product performance progression. While the concept of dominant design (Suárez & Utterback, 1995) is associated with a product and, therefore, ties in with Porter's (1980) definition of an industry as consisting of firms producing the same product, Christensen (1997) is more focused on the system-of-use. The term was coined by Cline (1985:217) to describe a system that uses combinations of hardware, people, and usually other elements to accomplish tasks that humans cannot perform unaided by such systems. Christensen (1997) describes the system-of-use as a hierarchically nested set of constituent systems and components organized along a specific design architecture, which performs a complex functionality for an end-user (Christensen & Rosenbloom, 1995; Henderson & Clark, 1990). The system-of-use concept along with the notion of delivering complex functionality clearly resonates with the expectations around HVM and especially with how the specific value that HVM realizes is understood.

Delivering complex functionality to a system-of-use is expected to take on the form of a product-service bundle, assembled from various different tangible and intangible parts, with each element featuring its own subsystem. This would

require a range of firms from various industries, all contributing to their respective subsystems and components. With an existing system-of-use, sustaining innovation is subjected to technology progression on established performance parameters, with technological advancement the consequence of a sequence of incremental changes (Christensen, 1992). Disruptive innovation eventually caters for different performance parameters that are initially unknown to the system-of-use, defying the cumulative sustaining process logic.

Innovation has been observed to exceed the confines of a single firm as well, which made Chesbrough (2003) to distinguish between closed innovation and open innovation. Closed innovation is based on a virtuous circle working within a firm, where R&D investment leads to technological breakthroughs that develop into new products and services that, in turn, increase sales and profits which then finance continued investment in R&D. This in-company virtuous circle is increasingly bypassed, with key personnel responsible for new products and services taking the outside option and exiting the firm to develop new products and business models financed by venture capital. It is not uncommon for these start-up firms to be acquired while the acquiring firms abandon their own R&D, as they buy-in the breakthroughs instead of developing new technology themselves. Similarly, not all internally generated innovations have to be utilized by the firm itself, as the technology can be licensed and applied by others. As a consequence of this increased sharing, firms must reconsider invoking intellectual property (IP) rights as a means to protect their knowledge from external use and also allow knowledge to be traded and exploited.

Chesbrough (2003) encourages firms to embrace the increasingly distributed nature of innovation, and indeed, HVM policy has grasped the concept

of open innovation (BMW, 2015b, 2016a; EC, 2013; Hauser, 2014; TSB, 2008). This also resonates well with the networked approach to manufacturing. However, refocusing innovation as a distributed activity requires some rethinking about the term “open innovation,” where the innovation practice advocated by Chesbrough introduces the question “just how open is open?” Sydow, Schüssler, and Müller-Seitz (2016) consider Chesbrough’s account of open innovation as confined to closed supply networks where the virtuous circle previously existing in-company is now implemented across a limited selection of firms. With network membership, there comes the question of governance and control. Here, Vanhaverbeke (2006) criticizes Chesbrough (2003) as being too focused on a focal firm that has to orchestrate the innovation process and exploit the innovations. He argues that distributed innovation requires coordination, especially with regard to who contributes what, who carries which costs, and how the proceeds will be distributed; yet it may not always be done by a dominant firm, especially when this coordination has to take place in the inherently ambiguous early development phase.

These ambiguities have been recognized by innovation process researchers (Van de Ven, 1986). The initial idea that the innovation process is a linear and sequential process from invention to diffusion (Rogers, 1962), starting with either a technology push or a marketing pull, has more or less been falsified (Galbraith, 1982; Van de Ven, Angle, & Poole, 1989). There are a number of areas of ambiguity: first with regard to the relative utility of a new innovative idea as compared with what is current; second, with regard to who will benefit when an innovative idea eventually transitions into common usage; third, with regard to what must be put in to develop the innovative idea; and finally, with regard to

what the context will allow for, especially as the realization of an innovative idea requires aspects of the context to also be changed.

Van de Ven and colleagues found the innovation process to be far from straightforward (Garud, Tuertscher, & Van de Ven, 2013; Van de Ven et al., 1989; Van de Ven, Polley, Garud, & Venkataraman, 2008). Instead of a single innovative idea being developed from invention to realization in a linear fashion, ideas take shape and change in the course of the process. Instead of one innovator – an individual inventor or a single firm – coordinating and driving the process, there are many participants taking initiatives and engaging and disengaging with time. Instead of an ordered network of people and firms transacting with each other, there is an expanding and contracting set of stakeholders pushing and pulling the process in different directions. Instead of one value system, there are several different contexts in which the process plays out. Instead of a simple cumulative process ending in a clear result, there is a labyrinth of divergent, parallel, and convergent trajectories. This complexity is rarely recognized in the HVM policy writings but needs to be incorporated before HVM can be fully developed.

Strategy Process and Practice, and Institutional Theory

Research under the labels of strategy process (Sminia, 2009) and of strategy-as-practice (Jarzabkowski & Spee, 2009) constitutes a parallel effort to dynamic capability and strategic change, with an aim to understand renewal and adaptation by focusing on the questions of how strategy is realized, how strategic change is accomplished, and how strategists do strategy? If there is a common thread in the findings here, it is that the activities that make up the process by which firms perform, take place within the confines of an institutional logic: “*the*

socially constructed, historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality" (Thornton & Ocasio, 2008, p. 101). At the firm level, this institutional logic has been elaborated as continuity in structure, culture, and strategy (Pettigrew, 1987); as an organizational culture (Schein, 1992); as a cultural web centered on a paradigm (Johnson, 1988); as a corporate context (Burgelman, 1983); and as a dominant logic (Prahalad & Bettis, 1986).

The institutional logic combines shared norms, values, and common understandings with an established distribution of resources and facilities. It enables and constrains the activity that takes place within a firm and allows participants to make sense of it all by legitimizing what they are doing. It is seen as supporting an effect of replication (Hendry & Seidl, 2003) and continuity (Sminia & de Rond, 2012), as norms, values, and understandings are confirmed and resource distribution and facilities preserved. Strategic change, then, manifests itself when changes to the institutional logic appear, thus legitimizing new activities and opening up new ways for the firm to perform (Burgelman, 1983; Gawer & Phillips, 2013; Johnson, 1988; Pettigrew, 1987). This enhances our understanding of what dynamic capability is about, as it refers to a capacity to manage such fundamental strategic change to the firm's institutional logic (Pettigrew & Whipp, 1991; Sminia, 2016).

Interestingly, institutional logic is evident within the domain that surrounds firms as well. At this level, it has been elaborated as an industry recipe (Child & Smith, 1987; Spender, 1989), a cognitive community (Porac, Thomas, & Baden-Fuller, 1989), and, indeed, institutional logic (Thornton & Ocasio, 1999,

2008). This indicates that the Porter (1980) notion of a value system can be added to in that it features an institutional logic that enables, constrains, and legitimizes the activities of suppliers, buyers, and rivals. Fundamental change like the emergence of HVM involves change to the institutional logic. There are many case studies on industry emergence and change, yet mostly done within the realm of institutional theory and institutional entrepreneurship, (e.g., Garud, Jain, & Kumaraswamy, 2002; Hargadon & Douglas, 2001; Munir & Phillips, 2005; Sminia, 2011), which have found evidence of the effects of the institutional logic in value systems. These studies also indicate that processes of emergence and change take on the form of a contest between the old way of doing things and a new way. As can be expected, fundamental change involves vested interests in combination with people and firms passionately defending their norms, values, resource distribution arrangements, and how value is appropriated, while others pursue innovation and change. The contest between the old and the new involves the institutional work of delegitimizing the existing way of operating that is embedded into the institutional logic of a value system, to make way for alternatives to emerge (Lawrence, Leca, & Suddaby, 2009; Lawrence & Suddaby, 2006).

Aspects of institutional theory and the recognition of an institutional logic that enables and constrains HVM innovation activity do feature in some HVM policy documents (e.g., BMBF, 2010; BMWi, 2015d; Hauser, 2010, 2014; Sainsbury, 2007; TSB, 2012). When the institutional logic appears, it is referenced as IP regimes, the availability of (venture) capital, or the overall innovation ecosystem and the extent to which government policy maintains a supportive innovation infrastructure. IP regimes refer to the specific norms and values

regarding knowledge ownership and whether and how this is regulated. The flow of investment capital is about resource distribution and how this is institutionalized. An innovation infrastructure is about knowledge flows and the effect of existing institutionalized arrangements on spreading new understandings and fostering new ways of doing things. IP regimes, availability of capital, and innovation infrastructures have been elaborated in terms of their enabling and constraining capacities.

What institutional theory suggests beyond the industrial organization, resource-based view, and dynamic capability approaches is that the institutional logic encompasses a wider range of enablers and constraints, which are manifested through technology regimes and resource flows, and through the formal and informal normative and constitutive rules underpinning all of these. It also indicates that innovation and value system development require an understanding of the role of the institutional logic in generating as well as impeding change and innovation. HVM outcomes such as sustainability, low carbon technologies, and wider CSR implications also resonate more with the notion of legitimacy as implied in the concept of institutional logic rather than just with Porter (1980) and his definition of end-user value.

One way of dealing with institutional logic and institutionalization when it comes to innovation is through the concept of path constitution (Garud, Kumaraswamy, & Karnøe, 2010; Sydow, Windeler, Müller-Seitz, & Lange, 2013). Resonating with earlier distinctions between incremental and radical innovation, between replication and strategic change, and between sustaining and disrupting innovation, path constitution consists of path extension and path creation (Djelic & Quack, 2007; Garud et al., 2010; Sydow et al., 2013).

Path extension takes place within a value system, thus referencing the design architecture of the product–service bundle to enhance end-user value for the system-of-use. Because the design is established, there is a more stable basis for cooperation, yet this stability itself allows competition to emerge as dependencies and capabilities are better understood. The innovation process features path dependence, as innovation activity is focused on improving the existing product–service bundle, simultaneously confirming the complex functionality as it is understood by the system-of-use as well as the legitimacy of the design architecture.

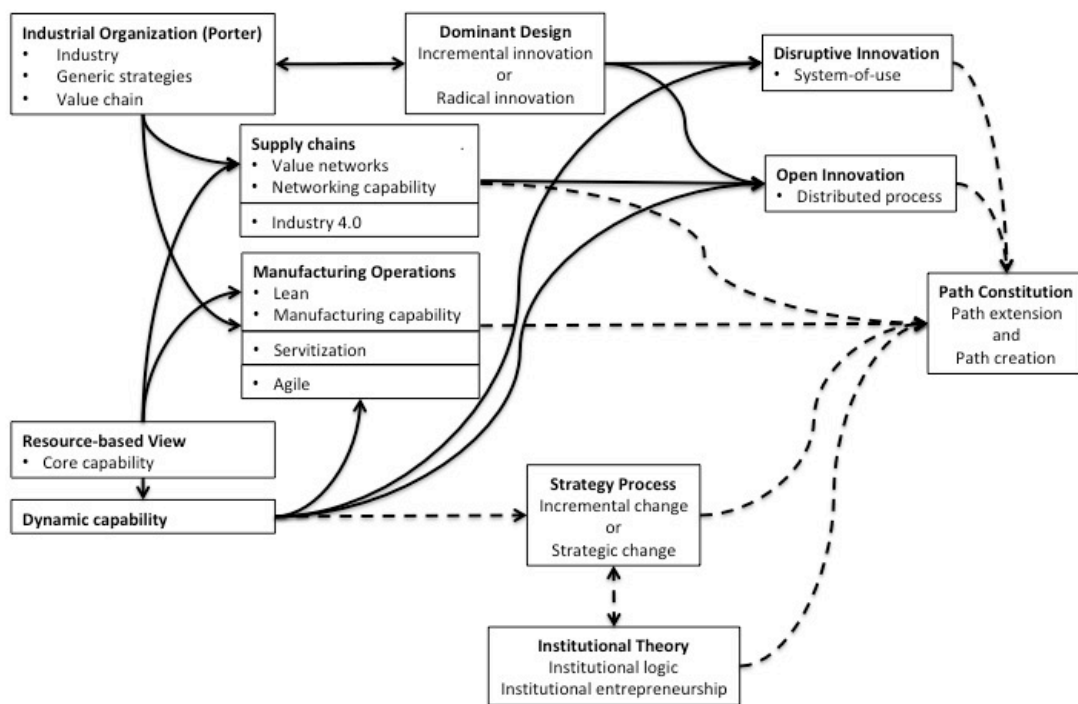
Path creation is about generating a new product–service bundle within an existing value system or possibly generating a completely new value system. It is about abandoning an existing path and creating something completely new. Path creation is ambiguous and open-ended, both in terms of who is participating and what the outcome will be, yet provides more scope for cooperation because it is largely unclear what competition will be about, which capabilities will matter, or what the functionality for the system-of-use will be. Yet, it is through path creation that radical innovation is generated.

Making sense of HVM

Having consulted the relevant literature on strategy beyond industrial organization economics, the resource-based view, and dynamic capability (see Figure 2), there seems to be more to HVM than manufacturing firms simply exploiting their manufacturing core capabilities and pursuing a focus or differentiation strategy to avoid competition on price. More fundamentally, these strategy theories, based as they are on strands of economics, share basic

assumptions about agency and the nature of competition, which has been summed up as “undersocialized” (Granovetter, 1985). In contrast, theoretical contributions from strategy process and practice research and institutional theory further develop firm activity and competitive dynamics as embedded in an institutional logic that is subjected to path constitution. This is where we extend the thinking about HVM as it emerged from the policy papers. We see path constitution as the key concept in developing HVM theoretically and empirically.

Figure 2: Extending Strategy Theory for HVM



This enhanced understanding has three consequences if HVM as a currently incipient phenomenon is to come into being. First, high value in manufacturing has to be understood as delivering complex functionality through product-service bundles to a system-of-use. This will be a matter of distributed activity, involving firms from many different industries. Consequently, the value system should be defined in terms of these product-service bundles and would

then include all the activities of the many firms and other organizations that contribute to realizing these bundles.

Second, because a value system features an institutional logic, it is subjected to path constitution and, therefore, always at risk of initiatives that aim to generate fundamental change. HVM is, therefore, inherently dynamic. HVM itself is such an initiative, but even when HVM has become an established mode of manufacturing, further initiatives can be expected to occur that fundamentally change HVM systems. Such initiatives develop as contests over the institutional logic that characterizes the value system (Sminia & de Rond, 2012). Manufacturing firms can never be sure that the institutional logic of the value system under which they operate will persist. This suggests that there is rivalry within an existing institutional logic with the dynamics urging firms to become better at what they are doing, which generates an effect of path extension, and there is rivalry about the institutional logic, with the possibility of fundamental change through new path creation.

Third, the inherent dynamics in HVM are a consequence of the simultaneous occurrence of cooperation and competition. Bengtsson and Kock (2000) recognize that competition and cooperation are based on contradicting logics of interaction, with competition informed by self-interest and cooperation based on mutual interest. Firms involved in HVM have a mutual interest in realizing and further developing the complex functionality needed to satisfy the system-of-use, while they each individually have to respond to the rivalry within and about the institutional logic. Such an in-built contradiction means that there will always be initiatives for change (Farjoun, 2010).

The simultaneous occurrence of competition and cooperation in HVM manifests itself by posing three enduring problems (Farjoun, 2017). These are the capability problem, the appropriation problem, and the governance problem. We found these three problems to be present in the policy papers as well (see Appendix 1). Consequently, a value system that delivers complex functionality to a system-of-use is expected to feature temporary truces around these conflicting interests, yet the path extension and path creation by which HVM changes and develops itself into the future will upset the truces that are in place.

The capability problem

Each HVM system has to feature a particular capability configuration. This is apparent from combining strategy theory with insights from innovation and especially with the notion of design architecture. A product-service bundle consists of various components fitting together in a specific way (Henderson & Clark, 1990). This corresponds to a division of labor between a set of co-specialized firms (Jacobides, Knudsen, & Augier, 2006) who each specialize in contributing specific capabilities to the realization of the product-service bundle. Participants in an HVM system have to combine their capabilities to deliver the complex functionality. Yet, it would be common for firms in the HVM system to have overlapping capabilities, thus leaving them competing for how much of a contribution each firm is allowed to make. This creates the capability problem because, despite this rivalry, a configuration needs to be in place through which firms combine their capabilities to deliver the complex functionality effectively.

A capability configuration consists of a set of truces between the various participants in the HVM system about the accumulation, evolution, and

deployment of capabilities. As capabilities develop and allow for path extension, these truces will become subjected to renegotiation. With path creation, the negotiation will be about what capabilities will become paramount for the newly developing HVM system, with potentially the eligibility of a firm contributing capability at all being at stake.

The appropriation problem

Value appropriation refers to how much of the proceeds of a product-service bundle end up with each firm in the HVM system (Coff, 2010; Cox et al., 2004) and is often associated with sustainable competitive advantage (Barney, 1991). To Chesbrough (2003), this is largely driven by IP. However, the problem is that when knowledge is used, it is often, in effect, shared, while, simultaneously, it needs to be protected, as it is the basis for value appropriation. Again, this insight follows from combining strategy theory and the innovation literature. Therefore, for HVM to function, there has to be an appropriation regime that allows firms to simultaneously freely utilize all available knowledge and still benefit from their individual knowledge base.

The second problem refers to the appropriation regime that has to facilitate the transacting, utilizing, and exploiting of knowledge to best realize the complex functionality. Again, this arrangement is a temporary truce because changes as a consequence of path constitution will affect the usefulness of specific knowledge. With path extension, this is about how the distribution of income recognizes whose knowledge is being utilized in the existing HVM system. For path creation, it is about what knowledge will become key in the new system and

whether this is recognized in changes to the appropriation regime (Jacobides et al., 2006; Teece, 1986).

The governance problem

As HVM exists as distributed activity, some form of coordination is required. Relationships vary between arm's length market exchange and forms of organized embeddedness (Granovetter, 1985; Uzzi, 1996). Open innovation (Chesbrough, 2003) and SCM (Cox, 2004) expects there will be a dominant firm that orchestrates all activity. Alternatively, the level of ambiguity present, especially in instances of path creation, could mean that specific arrangements emerge informally in the course of the process (Vanhaverbeke, 2006) or vary with specific activities (Lamming et al., 2000). Despite the need for coordination, many participants appreciate their autonomy because it enables them to pursue their own specific interests better. Again, this combines strategy theory with insights from innovation.

For HVM to function, a form of coordination needs to be in place to manage the realization of the product-service bundle as a collective enterprise. The third problem is, therefore, about the governance that is needed to facilitate the configuring, coordinating, and governing of relationships in the network to best realize the complex functionality while individual participants want to maintain their autonomy to pursue their own specific interests. The governance arrangement also is a temporary truce that is under constant threat as a consequence of path constitution. With path extension, the form of coordination that is governing existing relationships is at risk of renegotiation as the HVM system further evolves. For path creation, the more fundamental issue of which

relationships are going to be established for the new value system and in what form are at stake.

The three problems that we have identified are not necessarily unique for HVM and can be expected to appear every time when different firms have to simultaneously cooperate and compete. We argue that for HVM as an incipient phenomenon to come into being that these three problems have to be accommodated and also that any set of solutions is just a temporary truce. Any capability configuration, appropriation regime, or governance arrangement is liable to change because of the inherent dynamics and path constitution that HVM is subjected to. Having surveyed the underlying theories in government policy on manufacturing competitiveness and by introducing additional theory, we were able to enhance our understanding of HVM by pinpointing the specific problems that need to be accommodated and why. It also allows us to propose two strands of research by which both the HVM phenomenon and further theory can be developed.

Research that could help generate HVM

At present, HVM exists in the condition of prescience, and with prescience, empirical research is done through participating in practical problem solving. (Corley & Gioia, 2011). This form of engaged scholarship (Van de Ven, 2007) both helps to bring further shape to HVM and enhances our theoretical understanding. The distributed nature of HVM activity, featuring the three problems with regard to capability configuration, the appropriation regime, and network coordination, offers the enhanced problematization of HVM that this paper set out to provide. It

gives a theoretically argued indication of what practical problems need to be solved for HVM to operate effectively. Paths are in effect extended or created by developing and maintaining specific solutions as temporary truces. These three problems, therefore, underpin the research agenda by which HVM can be further developed. Moreover, by participating in problem-solving activity, academic research becomes impactful while simultaneously informing policy-makers how the required outcomes can be achieved.

We propose participation in problem-solving activity that will take place at two levels as solutions are sought for the three problems and HVM effectively is brought into being. First, at the value system level, competing systems search for the most effective formations and most useful mechanisms. Second, at the firm level, individual participants in the value system attempt to safeguard their ability to continue to participate and prosper and to effectively balance collective network achievement with individual gain. This then indicates two streams through which HVM research can develop.

Problem solving at the Value System Level

To this point, both the capability problem and the appropriation problem have mostly been elaborated from a competition viewpoint, with individual firms looking to enhance their performance on the basis of their core capabilities (Amit & Schoemaker, 1993; Barney, 1991; Coff, 2010). A key driver in this is the IP of a firm, as it safeguards the ownership and, therefore, the exploitability of the knowledge base that underpins core capability of a firm (Chesbrough, 2003; Grant, 1996; Teece, 1986). Albeit, the recognition of a division of labor between co-specialized firms (Jacobides et al., 2006) engaging in complementary activities

(Teece, 1986) brings cooperation into the fold. Such interdependencies are seen as evolving over time as a consequence of dynamic capability and innovation efforts of individual firms. Most effort taken in this research focuses on the firm and how the knowledge base and associated capabilities of a firm maximize the value appropriation of a firm. How a configuration of capabilities and an overall knowledge appropriation regime are established within a value system, and how these evolve over time through path constitution, has attracted less interest. Though, the mechanisms that balance collective achievement and individual gain are what is the most salient about understanding and contributing to HVM as an incipient phenomenon.

Network coordination up to this point has mostly been investigated from a cooperation point of view. Provan and Kenis (2008) suggest there is a choice between shared governance, governance through a lead organization, and governance by a network administrative organization. Shared governance would rely on the relative stability of a path extension trajectory that allows for coordination to be facilitated by trust and mutual understanding. A “lead” organization is advocated in the open innovation approach, where a focal firm is expected to take control (Chesbrough, 2003). Alternatively, innovation communities have been built around intermediary organizations that broker between various participants (Fichter, 2009). Occasionally, a formal overarching network administrative organization is established that governs membership and how firms and organizations interact (Sydow et al., 2016). Which of these coordination mechanisms is taken up as a solution or whether coordination is achieved through arm’s length market exchange (Uzzi, 1996), and how this

evolves over time through path constitution would enhance our understanding of HVM while it is taking shape.

The capability, appropriation, and governance problems, of course, are interrelated. Solutions to one problem will constrain or enable solutions to the others. This is part of the dynamic by which path constitution takes shape. Indications from institutional theory are that this plays out as contests between the old and the new (Battilana, Leca, & Boxenbaum, 2009; Garud et al., 2013; Sminia & de Rond, 2012). Path extension will only go thus far and eventually an HVM value system will have to engage in path creation. Rival trajectories will come and go, with institutional logics, technologies, competitive advantages, and partnerships emerging and gaining efficacy and also becoming obsolete. On the one hand, the overall process is indeterministic, as outcomes are generated depending on how the contests progress with time (Garud & Karnøe, 2001). On the other hand, the contest is bound by the circumstances within which it is progressing, creating effects of path dependency (Sydow et al., 2013).

The overarching concern is one of ambiguity. The emergence, continuation, and development of HVM systems depend on how participants will be able to handle ambiguity and collectively solve the three problems without knowing what the future might bring, while individual participants also will try to carve out viable positions for themselves. The expectation is that the shape and form of the solutions depend on how the contest evolves, while the way in which the contest evolves depends on the solutions that are put in place. To understand HVM and to contribute to its emergence, the overall quest then is to understand how ambiguity is settled and legitimacy and purpose generated for those involved

while simultaneously allowing for initiative and change in the value system to occur.

The ideal occasions to observe and participate in problem solving at HVM system level are the contests that come with path creation initiatives. The best way to learn about the functioning of a system is to try to change it (Warmington, Lupton, & Gribbin, 1977). It is also in instances of path creation that the need for problem solving is at its greatest, as new capability configurations, network coordination arrangements, and appropriation regimes are being established. By participating in problem-solving activity through engaged scholarship (Van de Ven & Johnson, 2006), the research will not only have impact because solutions will be created but also allow for theory building with regard to the functioning and performance of HVM.

Investigating firm participation in HVM problem solving

While the HVM phenomenon is emerging and HVM systems take shape, individual firms need to develop and maintain their positions. The capability configuration, appropriation regime, and network coordination problems pertain to the HVM system. Manufacturing firms have to participate in the problem solving with firm performance depending on the solutions and compromises, which are reached. A firm has to depend on its competitiveness, innovativeness, and social capital. This triple requirement for firm performance has rarely been investigated in a concurrent fashion.

Research that tracks the development of competitiveness of a firm would require an investigation on how a firm competes for advantage. This also pertains to social capital with regard to how a firm maintains and develops relationships

and with regard to innovation as to how a firm develops and utilizes knowledge. Because situations will be specific, conducting contextualist case studies of individual firms (Pettigrew, 1997; Welch, Piekkari, Plakoyiannaki, & Paavilainen-Mäntymäki, 2011) would be useful. This is a matter of tracking and comparing how manufacturing firms participate in the system-level problem solving, the contributions they make, and the interdependencies they have to deal with. By doing longitudinal comparative case studies between differently performing manufacturing firms within similar circumstances, we can come up with transferable insights (Pettigrew, 1990; Van de Ven & Johnson, 2006).

In conclusion

There are many hopes invested in HVM with regard to the viability and enduring success of manufacturing in high-cost economies. In addition, there are expectations of HVM contributing to issues such as climate change and corporate social responsibility. Despite the increasing rhetoric of policymakers, there has been little attempt to define and characterize what this incipient phenomenon is. In pursuit of this understanding, and building on the rudimentary framework proposed by MacBryde et al. (2013), we have consulted a range of strategy theories to reveal a complex interplay of factors, which must be disentangled for HVM to be understood and further developed. To help in this endeavor, this research has contributed the following.

First, in relation to the process of theorizing, it has contributed a multitheory synthesis drawing on a number of different approaches within the strategy field. It is expected that this pluralistic approach provides an impetus to enable further research to be carried out in this way.

Second, in relation to HVM itself we propose that HVM cannot be thought of as a firm-level phenomenon; it has to be understood as a distributed activity configured as a value system that realizes complex functionality for a system-of-use. Moreover, HVM is subjected to path constitution with possibly rival paths developing alongside each other while new paths are created that threaten the viability of existing paths.

Third, path constitution, we argue, plays out as solutions are generated for the capability, appropriation, and governance problems, and further, we have provided an informed research agenda taking these problems as the point of departure, which will allow further investigation and development of this insipient phenomenon and also contribute to strategy theory by developing further insights into how path constitution can be strategically navigated.

Fourth, and rather ironically, while much of the rhetoric surrounding HVM and, therefore, much of the accompanying policy direction are focused on the individual firm and its condition as a high value manufacturer, it is worth stating that, at this point, our conceptualization of the insipient phenomenon of HVM suggests that no firm can claim to be an High Value Manufacturer, but some firms may claim to be engaged as participants in HVM. This reframing already has significant implications for the way that governments and firms act in the pursuit of encouraging HVM in that policy needs to engage with the system level as much as with the firm level.

Finally, to further the pursuit of researching incipient phenomena, we propose the theory consultation as a literature review genre. Because we are dealing with a phenomenon-in-the-making, a body of literature that can be reviewed does not exist as yet. For the same reason, inductive research is not

possible. Instead, scholarly effort has to be guided toward specifying and engaging with the problems with which the phenomenon-in-the-making is associated and with the difficulties that arise while the phenomenon emerges. To do this, existing theory can be utilized to guide the problematization and indicate where research needs to be directed to characterize the phenomenon as it emerges and comes into being.

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Appendix 1. Data sources from policy reports and documents

DATA SOURCES	ABSTRACTED USE IN THE ANALYSIS
Data sources (UK)	
Porter and Ketels (2003), Birdi et al. (2003), Livesey (2006), Sainsbury (2007), TSB (2008), Martinez et al. (2008), Hauser (2010), TSB (2012), Foresight (2013), Hauser (2014), IfM (2016), HMGovernment (2017)	<p><i>Appropriation problem</i> The UK has to compete with economies with low (wage) costs, and it has to compete on value on the basis of knowledge intensive goods and services generated by continuous innovation. Exchange value as referring to the price that is realized at various stages in the value chain. Knowledge intensive products and services bring about IP concerns in the HVM system.</p>
	<p><i>Capability problem</i> The UK to move into high value and knowledge intensive products, to include service components, to be ever more efficient due to automation and information processing, to be more specialized, to be part of increasingly complex and global value networks. HVM firms deliver value by contracting for capability. Skill deficiencies are still considered a challenge, and include low quality SMEs that make up the local supply chain.</p>
	<p><i>Governance problem</i> Manufacturing defined as referring to the full cycle of undertakings from R&D, through design, production, logistics, and services, to end of life management, within an economic and social context. These activities can extend beyond the single firm. 'Industry' as the categorizer of manufacturing activity is flawed because the end product/service bundle is the result from contributions from firms from a variety of industries, which brings about a more complex network coordination problem in the HVM system.</p>
Data sources (Europe)	
EC (2010b), EFFRA (2010), EC (2011), EPSI (2011), EC (2012), EC (2013), IDEA_Consult (2013), BIO (2014), EC (2014), EFFRA (2016), IDEA_Consult (2016), Lowri (2015), BIO (2016), EC (2017a), EC (2017b)	<p><i>Appropriation problem</i> Europe needs to work on digital transformation and factories of the future concepts to manufacture high value and marketable products and generate economic value. the FoF roadmap sets a vision and outlines routes towards HVM technologies for the factories of the future, which will be clean, highly performing, environmental friendly and socially sustainable.</p>
	<p><i>Capability problem</i> Availability of 'fluid' production environments able to overcome traditional flexibility and elasticity limitations, through high speed and seamless reconfiguration capabilities of production assets adapting to dynamic changes of production needs, will be the key enabler for HVM. European companies are trailblazing in the world economy because they are able to integrate high value manufacturing with design and marketing services to create goods that customers want, but to remain competitive, Europe must build on those capabilities.</p>
	<p><i>Governance problem</i> Industrial production enabled by Industry 4.0 will be characterized by a strong customization of products with highly flexible production, extensive integration of customers and business partners in value-adding processes, and in linking of production and high-quality services leading to so-called hybrid products. Innovative business models are based on a dynamic network of companies, continuously moving and changing in order to afford more and more complex compositions of services and products. There is a strong need to create distributed, adaptive, and interoperable virtual enterprise environments</p>

	supporting these ongoing processes. In order to do so, new governance approaches must be provided for enabling and fostering the dynamic composition of enterprise networks.
Data sources (Germany)	
BMBF (2006), BMBF (2010), BMBF (2012), Kagermann et al. (2013), GT&I (2014), BMWi (2015a), BMWi (2015b), BMWi (2015c), BMWi (2015d), (BMWi, 2016a), BMWi (2016b), BMWi (2016c), BMWi (2016d), Prognos (2016), BMBF (2017), BMWi (2017)	<i>Appropriation problem</i> German manufacturing competes on value rather than price. To maintain this position, German manufacturing firms need to digitalize to raise productivity and customize offerings. Digitization opens up opportunities for disruptive innovation. Industry 4.0 will allow for optimization of the value system as well as tailoring and individualization of products and services for customers.
	<i>Capability problem</i> German markets become 'lead' markets where new capabilities are developed and nurtured first; when network partners collaborate; when R&D focuses on commercial application; when innovative start-ups are supported; when SMEs are supported to innovate; when IP is protected; when the innovation process is standardized; when public procurement is geared towards innovation; and when government is modernized.
	<i>Governance problem</i> Digitalization and Industry 4.0 as a disruptive innovation that will generate a system change in manufacturing industries, service industries, and society at large, which brings about a governance problem in the HVM system. A network effect – a positive external effect at the level of the network rather than the individual firm – that is influenced by the degree of interoperability of systems between firms in the HVM system.