

Making sense of high value manufacturing: relating policy and theory

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ABSTRACT

Government policy agendas in high-cost economies focus on manufacturing competitiveness promoting what they term High Value Manufacturing (HVM). HVM is seen as the solution to the problem of manufacturers in high-cost economies being outcompeted by those in low-cost economies. Despite the ubiquity of the term HVM, there is little academic engagement with it leaving HVM an under-theorized, emerging phenomenon lacking in academic legitimization. Our purpose is therefore to gain a 'theoretical foothold' to allow the phenomenon of HVM to be characterized. Policy documents from the UK and German governments and the European Commission are empirically analysed to determine the themes within their arguments. A literature consultation is conducted to reveal the underlying theoretical strands informing these arguments. A synthesis follows that relates the themes within the policy documents to the identified theoretical strands. We find that policy uses a plurality of multi-disciplinary, randomly drawn elements. However, despite this, some patterns can be identified with elements drawn from operations strategy, supply chain management and innovation. By defining these elements, this article makes sense of the policy rhetoric and builds a clearer understating of HVM so facilitating sharper and more structured research into its nature and its contribution to contemporary manufacturing competitiveness.

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Introduction

The term High Value Manufacturing (HVM) (Livesey 2006; MacBryde, Paton, and Clegg 2013; Martinez, Burgess, and Shaw 2019) has become widely used in UK government policy to illustrate how manufacturing sectors in high cost economies should react to increasing global competition specifically from low-cost economies (e.g. BMBF 2012; DBIS 2011; EC 2013; GT&I 2014). In the UK the policy agenda was initially set by a report commissioned by the Department of Trade and Industry (Porter and Ketels 2003). This report urged the UK government to move from an economy where competitiveness is based on cost minimization to an economy where competitiveness is based on value and innovation. This thinking gained traction with some influential thinkers with subsequent policy being formulated and implemented with special reference to HVM (Hauser 2010, 2014; Sainsbury 2007; TSB 2008, 2012). Outside the UK, the same phenomenon has also appeared in policy agendas but under different labels, for example in France ('La Nouvelle France Industrielle'), Germany (Industrie 4.0) and Europe (EC 2013; EFFRA 2010, 2016).

Although HVM has gained much exposure over the last decade or so, it has gained little in terms of definitional clarity. For some HVM is about organizing information flows within networks of firms, dubbed 'Industry 4.0' (BMBF 2012; BMWi 2015a; EC 2011; Kagermann, Wahlster, and Helbig

2013). For others it is about 'servitization' (Baines et al. 2009; EC 2010a; Martinez et al. 2008). Still others emphasize the development of advanced manufacturing technology to increase competitiveness and to deliver on sustainability (BMBF 2006; EC 2013; Edwards, Battisti, and Neely 2004; Hauser 2010, 2014; IFM 2016; Sainsbury 2007; TSB 2012). More ambitiously it has also been claimed that HVM is about lifecycle management, incorporating not just production activity but all activities including research and development, design, services and end-of-life management (Livesey 2006; TSB 2008).

However, despite this abundance of rhetoric, when viewed from the perspective of operations management, exactly what HVM is remains unclear. Currently work on HVM is dominated by the attempts of policy-makers and firms to solve the problems of manufacturing competitiveness that they are facing. These initiatives are affording HVM profile, but to date there has been no direct engagement by academia aimed at characterizing HVM as it develops. As a result academic literature on HVM is scant (MacBryde, Paton, and Clegg 2013) and this represents a substantial gap in academic enquiry. At present, for operations management researchers, HVM occupies the position of emerging phenomenon.

Management research tends to focus on theory rather than phenomena (Hambrick 2007; Schwarz and Stensaker 2014) and contributions are expected to be contributions to

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theory (Corley and Gioia 2011). However, this expectation is problematic, Schwarz and Stensaker (2014) contend that focussing too narrowly on making contributions within an established theoretical field is limiting often causing researchers to lose sight of the phenomenon that was the original object of inquiry.

This tendency therefore discourages exploration of emerging phenomenon and this is exacerbated by the lack of a recognized and legitimate methodological approach to researching phenomena. Traditional methodologies anticipate that an academic field is mature enough to have a sufficient volume of work published to make a conventional literature review possible. Emerging phenomena lack this maturity and therefore present a conundrum as a coherent body of associated literature cannot exist. Standard approaches to literature reviewing are therefore not sufficient. However many theoretical constructs that are now taken for granted originally appeared as phenomena. Chandler (1962, 1977), for instance, proved this in his seminal work on strategy and organizational structures.

To deal with emerging phenomenon (such as the subject of this paper) it has been proposed that researchers must 'develop an orientation towards prospecting' (Corley and Gioia 2011, p. 25). To enact this prospecting we believe that a consultation of existing literatures that are deemed relevant would be the correct initial approach. This approach would facilitate the identification of the strands that comprise the emerging phenomenon. A literature consultation in phenomenon-based research must be prepared to deal with a multi-disciplinary result that includes a multitude of existing insights to inform analysis of the phenomenon.

The purpose of this research is therefore to gain a 'theoretical foothold' and so set an academic foundation that will allow further characterization of HVM as a significant emerging phenomenon of interest to operations management. The objectives of this paper are threefold. First, to identify the arguments used across the breadth of policy documents. Second, to identify current theories within management thinking that can in some way contribute to the understanding of HVM, and third, to use these theories to create a more informed view of the HVM phenomenon that will support the development of a research agenda facilitating further study of this phenomenon.

This paper is structured as follows. The next section describes the custom methodology that was used to carry out this research. The findings are then presented in three sections ordered by knowledge area. This is followed by a synthesis where common themes are identified from the findings. Lastly, conclusions are drawn on the nature of the HVM phenomenon and suggestions are made on how it should be further investigated.

Methodology

The authors' initial interest in the HVM phenomenon grew over a period of time with involvement in knowledge transfer activities in manufacturing firms and commissioned research investigating the nature of manufacturing in high-

cost economies. Initial informal research, including policy consultations with government agencies and industry workshops, suggested that evidence of the existence of this phenomenon was abundant but predominantly anecdotal and fragmented, often scattered among diverse and inadequately archived sources.

This early research indicated that within a relatively brief period of time the term HVM had become central to the UK and indeed the wider international manufacturing narrative. However to research this phenomenon more systematically it was necessary to construct a custom research methodology.

Researching an emerging phenomenon is challenging due to its ill-defined nature (von Krogh, Rossi-Lamastra, and Haefliger 2012). In addition the HVM phenomenon is inherently multi-disciplinary composed of a plurality of elements, moreover its industry-spanning nature makes it difficult to scope clearly. The formulation of a custom research strategy was therefore required to relate theory with policy. This is summarized in Table 1.

An emerging phenomenon such as HVM, will not have a body of literature in existence as it has still to develop and coalesce. Therefore consultation of current literatures that are considered pertinent is the only method available. From previous analysis of policy documents it appeared that policy makers build their argumentation on specific strands from the fields of operations strategy, supply chain management, and innovation. These literature strands therefore formed the basis of the literature consultation.

In researching emerging phenomena it is clear that initial cues are required from the arena within which the phenomenon is emerging. For HVM these cues reside in the government policy documents that address national responses to the issue of manufacturing competitiveness. The literature consultation therefore supports analysis of these policy papers as the range of relevant theories and models it yields that are considered to have a bearing on HVM can be developed into codes that can be used to interrogate the policy papers.

The scope of our policy study was set as follows. First usage of the term HVM was identified in previous work published in 2003 so a temporal boundary was drawn at the year 2000 with 2000 to 2018 comprising the period researched. This initial usage was found in UK government documents so scope was set as documents either published directly or commissioned by government. To limit the scope to a manageable and coherent unit of research we chose the UK and Germany as two leading industrial countries that have committed to the HVM ideal. It was then decided to add a supranational perspective so the European Union was included because policies generated here influence both UK and German governments. As this research is dealing with what seemsto be a global phenomenon the documents were treated as a single data source.

In Britain the HVM narrative began in earnest with a report issued by the then Department of Trade and Industry (DTI) entitled UK Competitiveness (Porter and Ketels 2003). The DTI then became the Department for Business, Innovation & Skills (DBIS) that then more recently

Table 1. Research Strategy.

Stage	Purpose	Process	Outcome
Academic literature consultation	To identify current thinking within the operations management body of knowledge that may have potential to inform analysis of the HVM phenomenon	Literature Review to identify most relevant strands of literature	List of overarching theoretical themes, perspectives and models that may be useful in analysing the HVM phenomenon
Policy review	Part 1 – to identify the most likely sources of evidence for the phenomenon. Part 2 – to identify all policy documents relating to manufacturing published by that agency that may have contributed to the emergence of the HVM phenomenon.	Identification of government departments and attached agencies with any responsibility for manufacturing policy during the research period. Use of a focussed sample from high cost economies (UK, EU, Germany). Investigation of document archive within each identified department or agency by keyword search using the term 'manufacturing' and its synonyms Read data in order to understand what the data entails paying particular attention to patterns that occur in relation to theory	List of policy sources List of relevant policy documents List of preliminary codes
Synthesis	To identify the individual arguments and propositions within the relevant document that support the emergence of the HVM phenomenon	Abstraction of identified documents to capture the essence of the arguments within each using thematic content analysis Coding sub-themes on a latent level and linking them with strands of literature using N-Vivo Qualitative Data Analysis software Combine codes into overarching tensions to problematise the emerging phenomenon Coding reliability cheques to ensure coherent recognition of how themes are patterned and linked with literature strands.	List of abstracts capturing arguments within the identified policy documents. Comprehensive codes of data relating policy with theory List of tensions identified within HVM phenomenon

became the Department for Business, Energy and Industrial Strategy (BEIS). In addition other associated government agencies such as the Technology Strategy Board (TSB) and Innovate UK contributed to these debates.

In Germany, HVM was traced to Germany's high-tech strategy (BMBF 2006). Then and now, responsibility for manufacturing competitiveness is shared between the Bundesministerium für Bildung und Forschung (BMBF) and the Bundesministerium für Wirtschaft und Energie (BMWi).

In the European documents, the first evidence of HVM was found in the European Economic Recovery Plan (EC 2010a). While responsibility for manufacturing competitiveness is less clearly defined, and therefore less easy to trace, than that at national level, this responsibility has been absorbed by the European Commission (EC) and the Directorate-General for Research & Innovation (DGRI) in their Factories of the Future initiative. Overall, 52 reports/policy documents were identified as having some relationship with manufacturing. These are listed in Table 2.

Each document was reviewed in full in its language of origin and thematic analysis was used to identify the substance of the argumentation contained in each. Thematic analysis is a systematic coding and categorizing approach used for exploring large amounts of textual information to determine the structures and discourses of communication (Gbrich 2007). NVivo 11 Pro* qualitative data analysis software was used for coding purposes.

Braun and Clarke (2006) indicate that this analysis can be done on two thematic levels: semantic and latent. Semantic

analysis provides basic meanings derived from the data while latent builds upon this exploring 'the underlying ideas, assumptions, and conceptualizations' behind the data (Braun and Clarke 2006, p.84). This paper explores HVM themes on a latent level. The identified latent codes or themes comprise HVM paradoxes/problems/propositions which are repeatedly emphasized in the identified policy documents. Hence, the coding scheme emerged from reading the policy documents while looking beyond the policy rhetoric and capturing underlying ideas, patterns and concepts. Then, an interpretive analysis was conducted by focussing on conceptual orientation of data (Boyatzis 1998) and linking them to the previously identified literature strands, theories and models. In doing so, inter-coder reliability cheques were conducted to ensure research reliability. During this analysis it became apparent that strands of academic theory are recognizable that can be traced back to their original sources though these documents seldom refer directly to academic literature.

Findings

Relating policy to operations strategy

Porter's (1990) 'diamond' that model suggests manufacturing firms who find themselves unable to compete on costs are obliged to compete on value influences early HVM thinking. It was first introduced to the UK by Porter and Ketels (2003) and in Germany, referred to in the government's high tech strategy (BMBF 2006, 2010), while also appearing in the EU's

Table 2. Policy reports and documents.

UK	Germany	EU
Porter and Ketels (2003)	BMBF (2006)	EC (2010b)
Birdi et al. (2003)	BMBF (2010)	EFFRA (2010)
Livesey (2006)	BMBF (2012)	EC (2011)
Sainsbury (2007)	Kagermann, Wahlster, and Helbig (2013)	EPSI (2011)
	GT&I (2014)	
DBERR. (2009)	BMWi (2015a)	EC (2012)
DBERR (2008)	BMWi (2015b)	EC (2013)
TSB (2008)	BMWi (2015c)	IDEA Consult (2013)
		BIO (2014)
Martinez et al. (2008)	BMWi (2015d)	EC (2014)
DBIS (2010)	BMWi (2016a)	EFFRA (2016)
		IDEA Consult (2016)
		Lowri (2015)
Hauser (2010)	BMWi (2016b)	BIO (2016)
DBIS (2011)	BMWi (2016c)	EC (2017a)
DBIS (2012)	BMWi (2016d)	EC (2017b)
TSB (2012)	Prognos (2016)	
Dunkerton and Bustard (2013)	BMBF (2017)	
Foresight (2013)	BMWi (2017)	
DBIS (2014a)		
DBIS (2014b)		
Hauser (2014)		
IUK (2015)		
IFM (2016)		
HMGovernment (2017)		

Factories of the Future initiative (EC 2010a, 2013). This initial writing borrows from Porter's (1980, 1985) theory of industrial organization economics that sees firms as competing in an industry comprising a value system. If a manufacturer is denied the opportunity to succeed as the low-cost producer it must compete by differentiation or focus to achieve added-value.

Inherent in this argument is the implication that eventually price will become the ultimate competitive tool, even within more differentiated strategic groups and market niches. However, 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 are ignored. These bigger questions about change and development are particularly pertinent for HVM as an emerging phenomenon.

Porter's Industrial Organization approach is further supported by the resource-based view (Barney 1986, 1991; Peteraf 1993) that suggests manufacturing firms must find their competitive advantage in valuable, rare, inimitable and non-substitutable capabilities.

More crucially, manufacturing capabilities have been recognized as a source of competitive advantage (Brown and Blackmon 2005; Hayes and Pisano 2009; Schroeder, Bates, and Junttila 2002). Some HVM policy documents suggest that a manufacturing firm's capabilities should extend to product design, customization, information technology, and service (e.g. BMBF 2012; GT&I 2014; Livesey 2006; Martinez et al. 2008; TSB 2008) and other documents also emphasize the essential role of human resources in firm capabilities (e.g. BMWi 2016b; Sainsbury 2007; TSB, 2012). In effect, the resource-based view supplements the Industrial Organization approach proposing that a manufacturing firm's competitive advantage becomes sustainable if it is based on core capabilities that are unique to the firm (Amit and Schoemaker 1993; Barney 1986).

Interestingly, this synthesis of HVM policy documents with the strategy literature highlights a central tension in the policy agenda. This concerns the appropriateness of the industry as the starting point for the analysis. Livesey (2006) proposes that the product-service bundles that comprise the supposed output of HVM 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 (Vandermerwe and Rada 1988). Besides, these outputs tend to require inputs from a range of different firms who may not necessarily belong to the same industry. If HVM involves a value system, it would consist of firms from a variety of industries.

Building on the presumption that HVM involves the development, manufacture and delivery of complex functionality to an end-user by way of product-service bundles, describing the value system as being embedded within, or bespoke to, a particular industry becomes too limiting. In HVM the value system should be understood in terms of product-service bundles to which firms with relevant capabilities can contribute regardless of the industry that the firm maybe traditionally associated. This is because in many cases a firm's capabilities are not industry specific. This would therefore suggest there is more to HVM than manufacturing firms simply exploiting their manufacturing core capabilities and pursuing a focus or differentiation strategy.

The threads revealing how policy documents deal with issues of competitiveness can also be traced further into how operations management is carried out. Policy documents expect HVM systems to be simultaneously cost effective, value adding, and flexible (e.g. BMBF 2012; BMWi 2015a; EC 2014; TSB 2008, 2012). Interestingly early discussions on the management of manufacturing within firms were a harbinger of the contemporary HVM debates as initial attempts to understand how to build manufacturing capability were,

rather ironically, triggered by the increase during the mid-twentieth century of international competition.

Early work by (Skinner 1966, 1969, 1971, 1974) attempted to define what was wrong with US manufacturing firms as they struggled to compete in the international market. These findings suggested that the problem was twofold; first, the continuing American obsession with Taylorism (Taylor 1911) where efficiency and low cost were the priority; and second the emphasis on the development of manufacturing capability from the bottom-up instead of developing a manufacturing capability that follows from and is therefore coherent with competitive strategy.

Linking operations with competitive strategy began in earnest with the Hayes and Wheelwright (1984) framework that characterizes a firm's manufacturing operations against a ladder of capability (increasing from internally neutral to externally neutral to internally supportive and finally externally supportive). The third internally supportive stage in effect sees manufacturing as a core capability that underpins a manufacturing firm's competitive strategy while, interestingly in anticipation of later work on dynamic capability (Helfat et al. 2007; Teece, Pisano, and Shuen 1997), the fourth externally supportive phase sees firms actively foreseeing and developing new manufacturing capabilities.

In tandem with this reconciliation of operations with competitive strategy the pursuit of cost-based efficiency with neo-Taylorist methodologies such as 'Lean' (Womack and Jones 2003; Womack, Jones, and Roos 1990; Jasti and Kodali 2015) continued. More recently, as the 20th century made way for the 21st, and again anticipating the later HVM narrative, the conventional emphasis driving the efficiency agenda was coupled with an emerging agenda prioritizing adaptability. This new focus led to the elaboration of 'Agile' methodologies (Jin-Hai, Anderson, and Harrison 2003) that continued to recognize the place of efficiency while acknowledging that manufacturers face an increasingly unpredictable environment. Agile focuses on a manufacturer's ability to adapt to change by utilizing the latest technology and organizational knowledge. Lean and Agile, which exist in something of an uneasy alliance, are both referred to as fundamental manufacturing capabilities of HVM firms (e.g. BMWi 2016a; EC 2014; EFFRA 2016; GT&I 2014; TSB 2008).

It is now better recognized that manufacturing strategy should support competitive strategy (Brown and Blackmon 2005; Ward and Duray 2000). Though this recognition was somewhat presaged by Kotha and Orne (1989) who had already developed generic manufacturing strategies. Applying the explanatory logic of the resource-based view, manufacturing capability has been put forward as key to competitive advantage (Brown and Blackmon 2005; Hayes and Pisano 2009; Schroeder, Bates, and Junntila 2002). Despite this work, strategic management and manufacturing strategy, while finding some common ground, have not fully resolved into a coherent body of literature. This condition is apparent in the HVM narrative that often resorts to terminological differentiation with separate bodies of knowledge such as Agile and dynamic capability or Lean and cost leadership treading similar ground.

More recently another consideration has emerged as the association of manufacturing with the production of purely tangible goods has weakened. The convention in the past has been for manufacturing firms to regard services as add-ons with end-user value generally considered to reside in the physical good (Gebauer and Friedli 2005). Vandermerwe and Rada (1988) introduced the term *servitization* to describe how product manufacturing firms recognized the need to provide extra value and so created additionality in the form of maintenance, support and financing. This trend continued and currently some firms offer 'bundles' consisting of customer-focussed combinations of goods, services and knowledge. As previously noted this terminology of product-service bundles has been adopted by the HVM narrative (Livesey 2006).

Servitization is now an operations strategy in itself, with manufacturers who pursue a differentiation strategy creating custom packages for their customers (Baines et al. 2009; Davies 2004; Miller et al. 2002). Servitization has been advocated as one of the ways in which 'high value' is to be achieved (Baines et al. 2009; MacBryde, Paton, and Clegg 2013; Martinez et al. 2008).

For servitization to work for manufacturing firms, changes must be made to how they operate (Oliva and Kallenberg 2003). Operationally firms' activity must change from making sure the customer uses their tangible product properly, to making sure the product-service bundle fits well within the customer's operation. Commercially, the relationship must move from a product orientation conducted on a transactional arrangement, possibly emphasizing a short-term relationship, to a more strategic, value-adding arrangement focussed on a long-term relationship. It has been proposed that servitization can help manufacturers avoid competition on price especially when differentiation can no longer be achieved through tangible aspects of product quality (Coyne 1989; Frambach, Wels-Lips, and Gündlach 1997; Gebauer and Fleisch 2007).

Adopting the logic of the resource-based view, the capabilities needed to offer product-service bundles are expected to be the basis of sustainable competitive advantage (Auramo and Ala-Risku 2005; Gebauer and Friedli 2005; Mathieu 2001; Oliva and Kallenberg 2003), and to allow for the appropriation of a bigger and more stable share of the overall margin (Brax 2005; Mallaret 2006), especially when the customer becomes more and more dependent on the firm (Vandermerwe and Rada 1988). This shift towards product-service bundles has clearly informed those policymakers who quote HVM, as they notice the merits of a more comprehensive offering but also recognize the link to the service economy and its association with knowledge intensive work.

This analysis of operations strategy reveals within HVM thinking a subtle but definite pre-occupation with linking manufacturing capability with competitive strategy, sometimes developing in parallel with, sometimes drawing on, strategy theory, and then predominantly on industrial organization theory and the resource-based view. Interestingly, servitization, which is advocated as a specific way for manufacturing firms to establish a high value proposition

and escape price competition, implies a more embedded understanding of manufacturing strategy. First, servitisation advocates a move from transaction-based interactions between manufacturer and client towards longer-term relationships. Secondly, servitization requires fundamental change not only for manufacturing firms but for all firms in the supply chain including end-users (Sminia and de Rond 2012). If servitization is to become integral to the emerging phenomenon of HVM it is not something that can be developed by a manufacturing firm on its own. For servitisation to work all parties involved in the value system must appreciate that value is delivered as an overall product-service bundle. Servitization has to be legitimized among all who will be affected by it necessitating profound changes to the firms themselves and the value system's structure.

Relating policy to supply chain management

The preceding discussion conducted from the perspective of operations strategy identified within the HVM policy narrative signals that indicate the crucial role of the value system and its existence as a network of firms (e.g. BMBF 2012; BMWi 2015a; EFFRA 2016; Sainsbury 2007; TSB 2008). In consequence, threads of supply chain theory are easily identifiable.

The term Supply Chain Management (SCM) was coined around 1985 with instances of its use growing rapidly in the literature throughout the 1990s (Burgess, Singh, and Koroglu 2006). Initial work tended to describe SCM in terms of 'chains' of activities. SCM aims to arrange the various activities and relationships of the supply chain, facilitating and coordinating the flow of material, money and information necessary to provide the value that end-users demand (Russell and Taylor 2008; Sridharan, Caines, and Patterson 2005). While the 'chain' metaphor is of some use, writers do employ the term rather loosely, with most using it in reference to several interacting supply chains. Therefore the term 'supply network' suggests a more realistic representation of the complexities of SCM that implies firm interactions across many relationships (Cox et al. 2004; Lamming et al. 2000).

The term 'value-focussed supply management' was introduced by Raedels (1995) and very quickly became associated with SCM. From this point value was understood to have two aspects: 'tangible value' of product, also identified by Porter (1980), and 'intangible value' of the relationship between buyers and suppliers (Cox 2004). With the addition of the concept of value, SCM firmly shifted from its operational roots to embrace a more strategic role not least due to the association with Porter's (1985) value chain. Value-focussed supply chains therefore reframed the focus of study to include the combined network of firms constituting the entire conversion process, leading to the recognition that competition increasingly takes place on the basis of 'supply network versus supply network' rather than 'firm versus firm' (Shi and Yu 2013). Within this context, the concept of 'best value supply networks' is emerging as a core capability in terms of the resource-based view (Boyer and Hult 2005;

Ketchen and Hult 2007) as the supply network as a whole competes with other supply networks.

In supply networks that emphasize end-user value, competitiveness facilitated by speed, quality, flexibility and overall cost efficiency is prioritized over transaction costs (Morrow et al. 2007). HVM policy documents have embraced SCM by recognizing 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).

SCM emphasizes cooperation, yet there is also competition. For example, Cox et al. (2004) argue that the purpose of supply network strategy is the appropriation of value by powerful firms, which are in control of critical assets, at the expense of less powerful firms. However, others play down this form of rivalry, recognizing that in most situations competitive advantage is not easily secured with firm-specific core capabilities, and suggest that firms should cooperate to promote the supply network and the value created within it above their own attempts to capture a larger share of the value that exists within the network (Kim and Mauborgne 1997; Lamming 2000; Lamming et al. 2000). This means that firm-level strategy is still about positioning a firm, but the emphasis has changed from positioning within an industry to positioning within a supply network (Noke and Hughes 2010; Peppard and Rylander 2006). So firms are increasingly attempting to upgrade their capability in order to appropriate more value from the network (Edwards, Battisti, and Neely 2004; Noke and Hughes 2010).

The concept of the supply network gives further credence to the idea that HVM is about more than just a single firm competing in a value system on the basis of its core capabilities. SCM adds the insight that HVM is a distributed activity involving a network of firms, often in competition with rival networks. Such a network is characterized by a complex set of interactions, with goods, services, information, knowledge and capital flowing both vertically and horizontally as firms interact to realize value for all participants. Each participant may contribute elements to any other participant so there is no restriction in direction of flow.

However there is an added tension between the need for manufacturing firms to simultaneously cooperate to develop and maintain the supply network and to compete within it to appropriate the maximum proportion of the proceeds. SCM clearly reflects the distributed nature of HVM and currently is mostly about the establishment and maintenance of a network of relationships to realize value at supply network level and to appropriate the proceeds at firm level.

Relating policy to innovation management

Built into the narrative around operations strategy and supply chain management are elements of innovation theory. The majority of HVM policy papers propose that firms should escape price competition by innovating (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 and Ketels 2003; Sainsbury 2007; TSB 2008, 2012). This logic can be traced back to the work of Utterback and Abernathy (1975). They link a firm's innovation activity to the product lifecycle, with product innovation prevalent during the early stages, as firms develop the offering. Then midway through the lifecycle, product and production process settle on a dominant design that defines features of the product and end-user value. Later stages bring process innovation as competitive advantage is sought through efficiency gains as by this point price competition has become inevitable and it is only through continuous business model innovation that manufacturing firms may be able to escape.

Christensen's (1997) 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 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. Christensen (1997) focuses on the system-of-use. The term, originally coined by Kline (1985, 217), is described by Christensen 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 and Rosenbloom 1995; Henderson and Clark 1990). The system-of-use concept clearly resonates with the strategic and operational thinking that inhabits the HVM policy narrative as it informs how value can be delivered.

Firms deliver complex functionality to a system-of-use in the form of product-service bundles. These product-service bundles comprise a variety of components, some tangible and some intangible. A system-of-use is put together with contributions from companies from various industries that all contribute their respective product-service bundles. Within a system-of-use, sustaining innovation is exposed to technology progression on recognized performance parameters, where advancement comes as the consequence of incremental change (Christensen 2009). Disruptive innovation will, over time, bring different performance parameters that are initially unknown to the system-of-use, these performance parameters may supplant those that existed previously.

The observation that innovation exceeds the confines of a single firm and involves a range of firms and associated organizations linked together in delivering to a system-of-use made Chesbrough (2003) distinguish between closed innovation and open innovation and encourages firms to actively embrace the increasingly distributed nature of innovation.

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 networks where the virtuous circle previously existing in-company is

now implemented across a limited selection of companies. Apart from network membership there is also the question of governance and control. Here Vanhaverbeke (2006) criticizes Chesbrough (2003) as being too focussed on a focal firm which has to orchestrate the innovation process and exploit the innovations. He argues that although innovation activity still requires coordination, 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.

Again the HVM narrative with its preoccupation with network activity has firmly grasped the concept of open innovation (BMW 2015b, 2016a; EC 2013; Hauser 2014; TSB 2008) but again the HVM narrative is silent in relation to how networks operationalize to enable open innovation.

Discussion – drawing together the threads of HVM

While policy literature is diverse this analysis has identified the main threads of academic thinking implicit in the HVM policy rhetoric. Interestingly, it is apparent that the rhetoric of HVM is not based on any single position or indeed any coherent theorization. An understanding of HVM as manufacturing firms avoiding price competition in their industry by pursuing differentiation or focus strategies on the basis of their core capabilities, or by pursuing product innovation on the basis of their dynamic capability would be too simplistic. This analysis has instead revealed a deep and complex interweaving of elements.

Fundamentally this analysis demonstrates HVM is better understood as a distributed activity across a value system involving competing supply networks that deliver complex functionality in the form of a product-service bundle to a system-of-use. More significantly this analysis has revealed three inherent tensions built into the fabric of HVM that must be resolved for it, as a phenomenon, to grow. These tensions are a consequence of the distributed nature of HVM activity and from the conflicting interests between the various participants within the value system. More specifically these are manifestations of the simultaneous occurrence of competition and cooperation between firms within the value system.

The first of these is the capability architecture tension. Value systems feature capability configurations. This appears as a division of labour between a set of co-specialized firms (Jacobides, Knudsen, and Augier 2006) each contributing specific capabilities to create the product/service bundle. This arrangement is informed by the design architecture of the product/service bundle, as it consists of various components fitting together in a specific way (Henderson and Clark 1990). As a consequence, participants in a value system have to cooperate and combine their capabilities to deliver the complex functionality that is demanded by the system-of-use. Yet it is common for co-specialized firms in the value system to have overlapping capabilities leaving them competing for their share of the contribution. Despite this rivalry, for a value system to operate and deliver the complex functionality needed, a configuration needs to be in place

through which firms cooperate effectively by combining their capabilities. This creates the capability architecture tension.

Second is the value appropriation tension. Value appropriation refers to how much of the proceeds of a product-service bundle are returned to each firm in the value system (Coff 2010; Cox et al. 2004). This is largely driven by ownership of intellectual property (Chesbrough 2003). The close collaboration required for HVM systems to deliver complex functionality means that knowledge has to be shared while simultaneously being protected, as it is the basis for value appropriation. Therefore for HVM to function, the value system has to agree on an appropriation regime that allows firms to simultaneously benefit individually by appropriating an equitable share of value for themselves while freely sharing this knowledge for the greater good.

Third is the network coordination tension. With HVM existing as distributed activity, some form of network coordination is required. Relationships vary between forms of organized embeddedness and arms-length market exchange (Granovetter 1985; Uzzi 1996). Parts of the SCM literature (Cox 2004) and open innovation (Chesbrough 2003) come with an expectation that there will be a dominant firm which orchestrates all activity. Alternatively, specific arrangements emerge informally in the course of the process (Vanhaverbeke 2006), or vary with specific activities (Lamming et al. 2000), especially with the high level of ambiguity present in instances of path creation. Many participants appreciate their autonomy, despite the need for coordination, because it enables them to pursue their own specific interests better. However, for HVM to be successful with a network of companies creating a product-service bundle as collective enterprise, a form of network coordination needs to be in place.

Agenda for future research

These tensions of capability architecture, value appropriation, and network coordination therefore form the basis of the research agenda by which HVM can be investigated.

To achieve what policy makers want and build economies based on HVM this analysis suggests that three questions must be answered.

The first question is – what form of capability architecture is needed to facilitate the accumulation, evolution and deployment of capabilities across participant firms to best stimulate the creation of complex functionality for the system-of-use?

The second question is – what form of appropriation regime is needed to facilitate the transacting, utilizing and exploiting of knowledge to best realize the complex functionality for the system-of-use?

The third question is – what form of network coordination is needed to facilitate the configuring, coordinating and governing of networks to best realize the complex functionality for the system-of-use?

At this early stage of characterizing this phenomenon, research must be done at the value system level. Here supply networks pursue the optimum configuration while participating firms endeavour to secure their place by balancing the overall performance of the network with their own gain.

To this point both capability configuration and appropriation regime have been discussed from a competitive

perspective (Amit and Schoemaker 1993; Barney 1991; Coff 2010) and here ownership of Intellectual Property is key as it protects ownership and safeguards the exploitability of the firm's core capability (Chesbrough 2003; Grant 1996; Teece 1986). However the formalization of a division of labour between co-specialized firms (Jacobides, Knudsen, and Augier 2006) engaging in complementary activities (Teece 1986) introduces cooperation.

Conversely, network coordination to this point has been discussed mostly from a cooperation point of view. Provan and Kenis (2007) propose three options; governance through a lead organization, shared governance and governance by a network administrative organization. Understanding how these coordinative mechanisms develop would enhance our understanding of HVM.

The cooperation/coordination interdependency is seen as evolving over time as a consequence of individual firms' efforts to innovate and upgrade their capabilities. Most current research effort focuses on the firm and how the firm's knowledge base and associated capabilities maximize a firm's value appropriation. However the configuration of capabilities and how this shapes the overall value appropriation regime within a value system attracts less interest. Significantly this analysis suggests that the mechanisms that balance collective achievement and individual gain are what is most salient about understanding and contributing to our understanding of HVM.

Therefore the development and growth of HVM depends on how firms that participate in networks collectively deal with these three tensions so ensuring the success of the value network while carving out viable positions for themselves.

The ideal way to research the phenomenon of HVM is to observe the contests through which these tensions play out as new capability configurations, network coordination arrangements and appropriation regimes are being established. Within this, individual firms need to develop and maintain their positions. The performance and overall competitiveness of firms depends on the solutions reached. Research that tracks the development of a firm's competitiveness would require investigation into how firms compete for advantage by maintaining and developing relationships and developing and utilizing knowledge. Because situations will be specific, conducting contextualized case studies of individual firms (Pettigrew 1997; Welch et al. 2011) and how they develop and progress by being active in a HVM activity system would be useful. Further longitudinal, comparative, case study research between differently performing manufacturing firms should yield transferable insights that are relevant beyond the specifics of these case studies (Pettigrew 1990). This research will have impact, because solutions will be created, and will allow for theory building with regard to the functioning and performance of HVM.

Conclusions

There can be little doubt about the growth in the use of the term HVM. From its inception in the early 21st century it has become a ubiquitous term within manufacturing and political discourse. HVM is considered critical to the long-term survival and prosperity of high cost economies as a whole. But HVM as

a term is ambiguous, regardless of its place in policy rhetoric little has been done to characterize it.

Here we argue that HVM is a significant development with the potential to provide an alternative to cost-based competition in manufacturing and to contribute as an enabler as systems-of-use become increasingly technologically and logistically complex. As such, it is crucial that a clearer understanding of this phenomenon is reached.

We have consulted theory and identified recurrent themes across bodies of knowledge central to operations management. This consultation has revealed a number of connected elements, which must be researched further for HVM to be fully characterized. To aid this research we therefore contribute the following points.

First, to enable the ongoing process of research, this work has provided a methodologically informed, problem-based research agenda where further understanding can be gained by investigating capability architecture, value appropriation, and network coordination.

Second, it has contributed a cross-disciplinary synthesis and in doing this it has created a foothold in characterizing this phenomenon. It is hoped that this will allow additional research to be carried out in a similar way and therefore further inform practice.

Third, it is worth noting that though policy in relation to HVM is aimed at the individual firm this research has indicated that HVM must be thought of as a networked activity with individual firms in many ways submissive to the needs of the larger system. This reconceptualization has significant policy ramifications for how governments encourage firms to enact HVM.

Finally, as HVM features as a desirable future in government policy in countries like the UK, the USA, South Korea, Japan, Germany, and France but, more unexpectedly, also in India and China, the wider question of whether HVM will change how manufacturing takes place in the longer term still remains. As a limitation, this study focussed specifically on the high cost economies within the European context and future research should investigate more widely including developing nations. This increased scrutiny may help to establish HVM's position and more particularly whether it is a feature confined to high cost economies as they deal with competition from emerging low cost economies or whether it is a truly global phenomenon.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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