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## Open Innovation in High Value Manufacturing

### Abstract

The aim of this paper is to examine the concept of open innovation and understand if it occurs and how it occurs within the High Value Manufacturing (HVM) context.

There is a key theoretical relevance since open innovation has not been explored from a network based perspective. Similarly, there is a strong practical relevance for this research since policy makers in the EU (especially in the UK) are focusing on strengthening HVM in their economies but the role innovation, and especially open innovation, is not fully understood.

The methodology adopts an exploratory case approach within four manufacturing firms that we consider to be operating within a HVM context. Interviews with ten technical managers across the four cases were collected. NVivo analysis and data structuring based on Gioia et al. (2012) form the basis of the data analysis.

The findings suggest that many different 'modes' and types of innovation take place within the HVM context. Open innovation is witnessed more commonly from an 'outside in' perspective i.e. firms draw knowledge or technology from external sources into their internal innovation process. Our findings also suggest that open innovation occurs mainly in closed networks, with other firms within their supply chain. However, our findings also highlight that the maturity of technology and sector 'norms' may also have an influence on degree of openness.

### Introduction

The global manufacturing market is worth £6.7tn and the UK currently performs strongly as the 11th largest manufacturing nation worldwide ([www.hvm.catapult.org.uk/about-us/why-hvm-catapult](http://www.hvm.catapult.org.uk/about-us/why-hvm-catapult)). Manufacturing therefore represents an important contribution to the UK economy, with the government say that High Value Manufacturing (HVM) offers the best opportunities for economic growth. In the High Value Manufacturing Strategy 2012-15 from Innovate UK (2014), they define high value manufacturing as *"the application of leading-edge technical knowledge and expertise to the creation of products, production processes, and associate services which have strong potential to bring sustainable growth and high economic value to the UK"* (pp. 3).

While the term 'High Value Manufacturing' is commonly used within the UK (Porter & Ketels, 2003) there are similar initiatives in other parts of the world, such as 'Industrie 4.0' in Germany ([www.gtai.de](http://www.gtai.de)) which derived from a high-tech strategy by the German government or 'America Makes' ([www.americamakes.us](http://www.americamakes.us)) which is focused on specific manufacturing technologies such as additive manufacturing process. Surprisingly these strategies are not just in the high wage economies, initiatives such as 'Make in India' ([www.makeinindia.com](http://www.makeinindia.com)) which aims to transform India into a global design and manufacturing hub in response to falling growth rates or 'Made in China 2025' ([www.csis.org/publication/made-china-2025](http://www.csis.org/publication/made-china-2025)) which is an initiative to comprehensively upgrade Chinese industry to avoid being squeezed by both newly emerging low-cost producers and more effectively cooperate and compete with advanced industrialised economies. Thus we can conclude that the understanding of manufacturing and what it means to be a 'high value' manufacture is a critical concern for global manufactures, this means that our research into open innovation within this HVM phenomenon is highly significant in shaping the meaning of HVM.

HVM scholars have outlined the pivotal role innovation plays in understanding the HVM phenomenon. What is also highlighted is the role of networks and supply/value chains in contributing to the wider HVM trend. What is less evident is the role open innovation plays within this HVM context. Within HVM literature, innovation is used as a 'catch all' term or a silver bullet solution which means it ends

up becoming meaningless, often innovation is posited as the essence of HVM but much of the literature does not examine the role it plays within this context.

We propose that innovation spans the boundaries of firms in HVM and we aim to examine the modes of open innovation that might be occurring and what external actors might be involved in the open innovation process.

This paper outlines relevant background literature on HVM and open innovation, paying particular attention to the modes and models of open innovation. It then details the exploratory analysis from our case studies and interviews and presents the common themes emerging from our data concerning open innovation. Given our limited data set, the paper then identifies areas for future research and how our work may develop in the future based on our results and experience with the methodology employed in this research.

## **Background Literature**

### ***High Value Manufacturing (HVM)***

The focus on HVM from various governments and different academic teams means that it is frequently used in policy and management vocabulary. However, High Value Manufacturing (HVM) is a complex phenomenon as such it can be difficult to define. Many studies of HVM concur that cost-based competition is no longer enough (TSB, 2008; 2012), this means manufacturers who aim to be high value need to compete on adding value for their stakeholders. Conversely, the concept of 'value' seems to be the impediment in defining 'high value'. In fact, Livesey (2006) lays blame on the shifting characterisation of 'value', stating that "*High value manufacturers can create value in a variety of ways. For example they may have unique production processes, high brand recognition, rapid delivery times, or highly customised services*" (pp.1).

HVM it is often used as a highly ambitious term that is becoming interchangeable with the term innovation (Edwards, Battisti, & Neely, 2004), where HVM is seen as the innovation strategy that many manufacturing firms should be aspiring to. From our review of HVM literature and policy documents, HVM appears to exist as an attribute of a firm, a network or an industry. Some authors (i.e. Dunkerton & Bustard, 2013) go as far to say that only certain type of industries or sectors can be considered as HVM e.g. high tech firms. Thus it would seem that HVM as an expression is a 'catch-all' term where firm defined as HVM are expected to deliver innovation, be operationally excellent, have superior brand recognition and contribute to wider society (Martinez, Neely, Ren, & Smart, 2008).

### ***Open Innovation***

The term 'open innovation' was coined in 2003 by Chesbrough in his seminal book on the concept, since then open innovation has become a term synonymous with modern approaches to innovation (Cassiman and Valentini, 2015). Essentially open innovation means that the innovation process is permeable meaning that "there are many ways for ideas to flow into the process, and many ways for it to flow out into the market" (Chesbrough, 2006: 3). This definition is important within the HVM context since delivering value can be complex if the offering is constructed from various different components and services. This is likely to require various firms from diverse industries who all contribute their respective technology, products, skills, knowledge and services to the wider network. The way innovation occurs within this HVM context across the various firms has received little attention in the studies of HVM.

This understanding that innovation transpires across the boundaries of individual firms and actually involves many actors linked together in formal and informal innovation activities has resulted in

Chesbrough (2003) distinguishing open innovation from the traditional closed model of innovation. Closed innovation is based on the premise that investment in R&D results in technological discoveries which advance into new products and services which increase profits that are then reinvested into the development of further new technologies. However, within open innovation this process is opened up with ideas and technologies being developed externally to the firm. What also occurs is the spinout of ideas, technologies and business models from the open innovation activities to other firms who perhaps create new ventures. A major outcome of the open innovation concept means that firms must reassess the role intellectual property (IP) plays as a strategy to defend their propriety knowledge from its use by external actors. Open innovation theory says that knowledge needs to be exchanged and utilised to allow competition between internal and external process that will results in new knowledge generation and consequently innovation.

While much of the literature on open innovation has been discussed in a positive way, Vanhaverbeke (2006) criticises Chesbrough (2003) as being too focussed on the focal firm. Many of the studies of open innovation seem to focus on this central firm who controls and manages the innovation process and ultimately take advantage of the innovations that come from the process. He wants to extend open innovation to all firms that contribute in the wider network and not just those who are in control of the innovation process. Vanhaverbeke does argue that this still requires management, particularly around issues such as what contribution firms make, how costs are distributed, and how the profits will be allotted. He does stress that this management does not have to be undertaken by the focal firm and emphasises that the coordination will often occur in networks that will be operating in the fundamentally uncertain development stage of innovation.

There has been further criticism of the 'openness' of the open innovation approach, Sydow, et al. (2016) believe that open innovation is never fully open and actually resides in closed networks of clique firms, thus outsiders would find it difficult to participate in this type of innovation process.

#### *Models of open (and network) innovation*

Our review of the literature has shown that it is difficult to separate the concepts of open innovation and network-centric innovation and each could be considered part of each other. For the purposes of this paper we are interested in both theories of innovation i.e. innovation that can be considered as taking place outside the boundaries of the focal firm.

There are a number of ways in which open innovation has been conceptualized. West et al. (2003) identify open innovation research as being focused on 'inflow' or 'outflow'. These models are often referred to as **outside-in**, where firms draw ideas, knowledge, and people into the firm for innovation purposes and as **inside-out** where firms push their partially developed ideas to external firms to be fully developed and commercialised). Enkel et al. (2009) develop open innovation as '**coupled**' model, with innovations seen as co-created with complementary actors).

Conway and Steward (1998) develop models for network innovation in further detail. Rather than just thinking about the flow of the process, they classify four different network perspectives on innovation research: Portfolios of strategic alliances; Networks mobilised for a specific innovation; Regional and business groups; Diffusion and commercialisation of innovations. Nambisan and Sawhney (2010) build on the key concepts from Conway and Steward (1998) and outline four models of network-centric innovation, based on innovation space (i.e. how defined is the nature of the innovation) and network leadership (i.e. how the actors come together and share within the network). Innovation space can either be defined or emergent while network leadership can either be centralised or diffused. This generates the four models of Orchestra (innovation is defined and the structure of the network is centralised); Creative Bazaar (innovation is emergent and the structure of the network is centralised);

Jam Central (innovation is emergent and the structure of the network is diffused) and MOD Station (innovation is defined and the structure of the network is diffused), see figure 1.

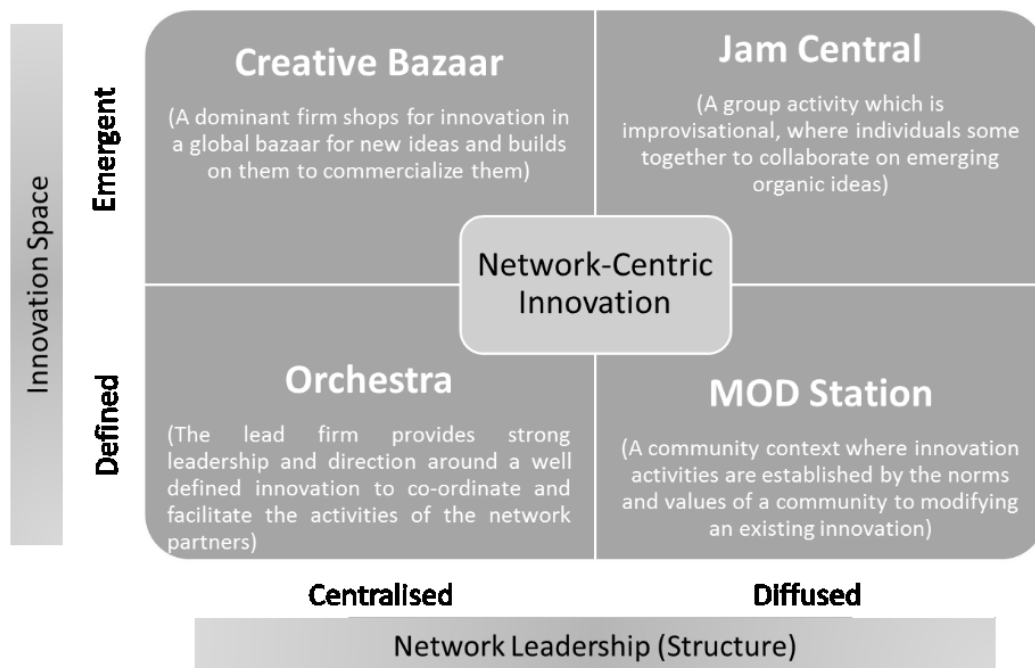


Figure 1. Four models of open innovation (Adapted from Nambisan and Sawhney (2010:131))

There is a wide body of work emerging examining open innovation from many aspects, Gassmann (2006) highlights that the wealth of empirical studies in this area shows “that open innovation has different characteristics and has to be looked upon from several angles” (pp. 227). Our review on extant models of open innovation however shows that most models have some consideration of the characteristic of the innovation as well as the types of networks. For the purposes of this research we will use the models of open innovation outlined in the previous section (i.e. the models in Figure 1 as well as the three models defined by Enkel et al. (2009)) to attempt to understand if open models of innovation occur within the HVM phenomenon.

HVM scholars have outlined the pivotal role innovation plays in understanding the HVM phenomenon (Martinez et al., 2008; TSB, 2008, 2012). What is also highlighted is the role of networks and supply/value chains in contributing to the wider HVM trend. What is less evident is the role open innovation plays within this HVM context. Thus our exploratory research will provide some key illumination in this interesting area. Our empirical work will explore the modes and models of open innovation that might be occurring and what external actors might be involved in the open innovation process.

### Methodology

The setting for our research is in the phenomenon of HVM, to this end the selection of our cases was important. While we believe that HVM transcends the boundaries of firms and that HVM is resident in a network of firms all working towards end-user value, for the purposes of this initial research we have adopted a focal firm perspective for the selection of our cases. Our cases are selected based on their manufactured products contributing to a product-service bundle that delivers complex functionality to an end-user. The cases selected are all located in Scotland, UK. Two of the cases (LTech and Pharma) are business units of larger firms with headquarters out with Scotland, the remaining two cases (GMachine and GGen) have their headquarters within Scotland. The four cases selected for

this preliminary study of Open Innovation in HVM all have varying degrees of technological complexity plus differing levels of maturity of their technology. Table 1 summaries the composition of our cases and the corresponding number of interviews undertaken in each case.

The data analysed for the research presented in this paper is part of a larger data set, examining the wider concept of HVM. For the purposes of this paper we are concentrating only on the interviews which are concerned with innovation, product development and technology development (ten interviews). The main sources of data was a series of semi-structured interviews (each lasting 1 to 1.5 hours each), ten interviews were conducted with senior managers who had responsibility for technology and product development such as; Engineering Managers, Technical Directors and Product Managers. The unit of analysis was the whole organisation or business unit, rather than just a specific innovation project. Thus the questions asked in these interviews focused on how innovation and technology development was done within each of the firms (or business unit) e.g. where new ideas came from, how they thought about innovation and how it was managed. All interviews were digitally recorded and transcribed prior to analysis.

Case name	Case description	Number of interviews
LTech	Business unit of a large technology based firm	3
Pharma	Business unit of a large pharmaceutical company	2
Gmachine	Small machining manufacturer	2
Ggen	Medium sized technology and manufacturing firm	3
<b>Total</b>		<b>10</b>

*Table 1. Composition of cases*

The transcribed interviews were imported into NVivo 10 to allow us to analyse the data, initially text frequency searches (e.g. wildcard searches such as innov\*) were performed to enable data reduction and examine what the interviewees had said regarding their approach to innovation. Since we were examining open innovation we were interested when external actors were mentioned such as customers, competitors, end-users, original equipment manufacturers (OEMs), suppliers. The sections of the transcriptions returned by the searches were coded In Vivo to allow us to capture the first order quotes from each of the interviews, Table 2. In line with Gioia et al. (2012) we used these first order quotes to develop a qualitative data analysis structure identifying first order concepts (modified from the In Vivo quotes), second order themes (using theoretical constructs) and aggregate dimensions, Table 3.

### **Findings and Discussions**

The findings are organised by presenting the initial 'In Vivo' quotes arranged by case firm, this allows the 'raw' data to be witnessed and add the richness to the analysis. The data structure is also presented to see the steps between abstractions of the data from the rich case to the emerging themes. Each of these themes are then examined in greater detail using exemplary quotes to illustrate the findings from the interviews.

Case name	'In Vivo' Quotes (initial coding phase)
LTech	There's a centralised new product introduction process. That's not a perfect situation because it's a one process fits all or it tries to be a one process fits all, it doesn't quite. There's quite a high motivation for us to produce a version of that that's specific to this site but it's quite an undertaking to do that so we've never done it
	Sometimes but we lean on customer input; we lean on our strategic corporate input to get all of this data in.
	A very open model, you get ideas from anywhere. Yes, exactly, there's no limit to where it all comes from.
	Companies will say there's some multimillion industry out there but, actually, if you look into the depths of it, they're not mature markets that are pulling it. So there is a lot of stuff being done there, which is creating technology ahead of demand and that's partly by European funding, which is a good thing and we do engage in that.
	So it usually works that we hardly ever do customer driven development. We sometimes do and it's paid customer development and other parts of the firm do that. We have not done so much of that, we tend to know about a market and know the direction that that market is going in and produce a laser specifically for it.
	We take local whenever we can but there are some enabling technologies that we need to go elsewhere for and unfortunately in order to be producing something that's reasonably state of the art then you have to go single source and get the enabling technology.
	On the industrial side if you're a large industrial integrator it's quite difficult to buy from small companies who have reliability issues and support issues. You tend to buy from another big company that you know is going to be there to support you so on the industrial side that.
	So they see it all, we go to conferences. I go to them so we've got not only the engineers, not only the product line managers but strategic marketing. Everyone's monitoring both the technology and the markets and making good matches between the technology and the markets but you kind of need to understand both.
	Between us and our main competitor we automated that technology.
	Pharma
	There is very little in the way of process that we can copy from other people so we have to design our own.
	We have visitors from the global portfolio group who go around and link up the compounds and the technology the organisation has to couple them together.
	People come up with suggestions from all over the place but it has to link to our business model.
	We have to be very careful, don't talk about it outside of the building, don't present it at a conference, don't talk about it in the pub.
	Our development is very, very heavily driven by the health authorities in each country.
	The technology this company was founded on was a spin out from a university.
	Other companies manufacture some of the machines for us...they are custom built, unique pieces of equipment.
	So the ideas come from the areas we're interested in, from the clinicians, from the technologists...it does help having those contacts.
	We have a stage-gate innovation process and lots of ideas are either thrown away or implemented...the ideas have to be related to the current business model or they are thrown away.
	We sponsor PhDs and MScs to allow us to go right through to clinical trials.
GMachine	The companies that make the machinery have got big R&D departments...new technology comes along and we want to be able to take advantage of that. We rely on the machine manufactures to be innovative and then we take advantage of that innovation by investing in that equipment.
	The work we have done with SMAS and the installation of a new ERP system has been innovative for our business.
	We have audits from the big manufactures
	We were doing some design work with one of our customers...we have made a couple of components and there R&D department will run them to destruction. We are able to offer design suggestions to customer now.
	We are dealing with end-users, but we're dealing with original manufacturers as well.
	We've all got our own wee niche area and we do compete with certain of these guys in certain areas, but quite often there's enough work for everybody and we help each other out a bit.
	Quite a lot of companies are out customer and suppliers...and we swap work back and forward with them quite a lot.
GGen	Sales person who comes in with a requirement from the field.
	We have a cross-functional team going out to all our customers and everyone we touch to understand what they expect from us.
	Sales and marketing are now going to engineering with ideas, rather than the opposite way around.
	Basically the product is built of parts that we buy in from places...there is a little bit of innovation how it is put together.
	We are nurturing and capitalising on our relationships with our OEMs.
	We have been working with our compressor supplier to make the product smaller and last longer.
	We're now in with the designers of the instruments, looking and discussing with them what is the next generation going to be. There's a much more collaborative approach.
	We are in the privileged position as working with all three main OEMs and we get to see what they're forecasting. We show we have integrity by not discussing each company with the others.
	The service engineers are always out...feeding that information back, and even with the sales people when they're talking to customers obviously, they are getting information back as well.

Table 2. 'In Vivo' Quotes by case

1 <sup>st</sup> order concepts	2 <sup>nd</sup> order themes	Aggregate dimensions
Engaged in funded projects such as Horizon 2020 (LTech)	Orchestrated open innovation	Structure of Open Innovation Model
Joint technology development with competitor (LTech)	Open innovation in closed network	
Work with machine suppliers for custom technology (Pharma)		
Sponsor PhDs and MScs (Pharma)		
Work on designs with customers (GMachine)		
Work with end users and original manufacturers (GMachine)		
Nurturing and capitalising on relationship with OEMs (GGen)		
Working with suppliers on technology development (GGen)		
Ideas from everywhere (LTech)	Internally open	Degree of openness
Attendance at conferences (LTech)		
Coupling of compounds and technology within the firm (Pharma)		
Suggestions from everywhere (Pharma)		
Limited customer driven development (LTech)	Externally closed	
Limited interaction with SMEs (LTech)		
Don't talk about ideas outside the building (Pharma)		
No conferences (Pharma)		
Technology came from university spin out (Pharma)	External sources of innovation	External knowledge
We rely on machine manufacturers to be innovative (GMachine)		
Work with SMAS and ERP providers (GMachine)		
Sales based requirements (GGen)	External knowledge sourcing	
Information from service engineers (GGen)		
Swap work back and forth with customers and suppliers (GMachine)	Regional clusters of similar firms	Clusters

Table 3. Final data structure

### **Structure of Open Innovation Model**

#### *Orchestrated open innovation*

Our findings show that only one of our case studies were involved in large consortia based open innovation. Our LTech case study is part of a large scale orchestrated model of open innovation via EU funding which echoes the findings of Sydow et al. (2012) "The increase of R&D consortia indicates that today new technologies are developed by sets of organizations in increasingly networked fields" (pp. 912).

*"So there is a lot of stuff being done there, which is creating technology ahead of demand and that's partly by European funding, which is a good thing and we do engage in that". (Product Manager, LTech)*

This quote from the Product Manager shows that this type of Orchestrated model of open innovation, is not 'conducted' i.e. led by a focal firm but rather by EU policies and government consortiums that pull together various firms from around the EU to work on new technologies that do not yet have a commercial use. No other case in our data set mentioned working in this type of open model of technology development, this could be due to the technology embedded in LTech's products which is currently being viewed as a 'hot' technology. The above quote also shows that the firm is aware that this type of funding and development opportunities exist and that they can actively engage in these orchestrated models of open innovation.

#### *Open innovation in a closed network*

This mode of open innovation seemed to be the most prevalent within our case firms with many of the interviewees detailing links and relationships with suppliers and original equipment manufacturers (OEMs). Sydow et al. (2016) believe that firm boundaries are never truly 'open' and there is always some element of 'membership' to participate in open innovation. This seems to be the case for many of the firms in our study. For example in our LTech case, the General Manager shows



that by working with a main competitor they were able to engage in open innovation which allowed co-opetition to be achieved between these two firms:

*“Between us and our main competitor we automated that technology so it really freed up the person to buy all the kit and do the experiment themselves. That market went from ten a quarter to like 80 a quarter and completely revolutionised that market so that was enabling... that was a technology... not necessarily the technology of how the product worked but automating it, that technology completely liberated that market”.*  
(General Manager, LTech)

This quote exemplifies by the two competitors opening up and sharing the technology development of their products they actually significantly increased the volume of products that both firms could sell. This can often seem counterintuitive to firms locked in competitive conflict with each other. It could be argued that because the technology is sophisticated and complex then there is cognitive legitimacy to join together to spread the risk of the development of a technology that liberated the market.

Contrastingly, some of the less complex technology based cases in our study have been involved in open innovation along their supply chain, either towards their customer as outlined by the Managing Director of GMachine:

*“We’re only able to help them with the design of the technology itself, not the actual structure of the product. Our biggest customer at the minute is this North American customer that we’re exporting to...we were doing some work with this design package with them at the minute, this is something we’ve not done before.”* (Managing Director, GMachine)

The above quote illustrates that a new IT based design package has allowed the firm to open up and help their customer with design based problems. This is something which is new to this case firm who previously did not offer this type of service to their customers, what was clear from this interview was because their biggest customer was asking for help played a key part in the decision making process of getting involved in a more participative open innovation relationship with them.

Other firms within our research were part of complex product-service systems and they themselves were suppliers to larger complex products which meant that the original equipment manufacturers (OEMs) have a powerful role to play in the mode of open innovation. In our GGen case they employed a dedicated person to work with all the OEMs to integrate with their ideas of the future showing that this is an outside-in approach to open innovation, as they are drawing in all the information from the various OEMs and this has allowed this particular case firm to develop joint innovations with some of the OEMs:

*“Through capitalising on our contacts within the OEM organisations. We have one guy (who) was very good at was building up the OEM relationships...he’s taken a full time OEM relationship management role where he’s travelling all the world speaking with the OEMs constantly, and finding out what’s going on with them, what new products are coming through, are there any issues in the field, what do we need to be aware of, talking about pricing, talking about forecasts, these sorts of things.  
So, he’s a big conduit of information back into product management now. He will get all the headline information and then once we get a project on the go then it will be the product manager that then takes it over and does all the detailed work in terms of the timeline plans and things like that.”* (Engineering Manager, GGen)

In GGen they not only went upstream towards the OEM for ideas and collaborative innovation, they also went towards their own supplier to work on specific innovation projects with one of their key suppliers:

*“What we’ve been doing over the last two years is working with our compressor supplier so it gets to the point where we can get one compressor that will last over 8,000 hours”* (Engineering Manager, GGen)

From this quote it can be seen that GGen are interested in building up relationships with both OEMs (their immediate customer) as well as their suppliers in order to develop on their existing product.

Tidd and Bessant (2003) identify a list of types of innovation networks and many of the examples of open innovation in a closed network we have identified through our interviews could be classified as supply chain learning which is defined as “Developing and sharing innovative good practice and possibly shared product development across a value chain” (pp. 309). In our small scale sample of cases we have identified that all of the cases are involved in developing technology or products within their immediate supply chain.

### ***Degree of openness***

#### *Internally open*

Another related concept which we did not touch upon in our background literature is the openness of the firm. This could be how open they are to ideas from within their own organisational boundaries as well as how open they are to external ideas and knowledge. What our findings show is that in the two firms where knowledge appropriation are important to their perceived competitiveness (LTech and Pharma), they spoke more about ideas being drawn from within their organisational boundaries. This makes sense since they are not searching externally for ideas due to risk aversion around intellectual property (IP) rights, then they are going to focus on getting more ideas internally generated. LTech seem to be more ‘open’ as they also attended conferences and present their findings to academic colleagues. Internally they seem to generate ideas from all over the firm and they refer to this as an open model:

*“A very open model, you get ideas from anywhere...there’s no limit to where it all comes from”* (Product Manager, LTech)

In contrast our Pharma case seem to have a dedicated team which look to do combinative innovation where different technologies are joined together to see what works and what might be commercially viable. The quote below from the R&D Director highlights this process:

*“Our global portfolio group who are looking at areas of interest, at things that they think that there’s a clinical need and can then look at the compounds that the organisation has and look at the technology the organisation has to couple them together”.* (R&D Director, Pharma)

While Von Hippel (2005) talks about democratizing innovation internally within the firm and this is evident in some of the firms in our cases. Pharma seems to be firm which has limited open innovation either internally or externally, this could be due to the highlight competitive and price sensitive nature of the pharmaceutical industry, where survival is often about IP protection. It would seem that Pharma is trying to be internally open to be innovative around compounds and technologies which are currently existing in the firm, but this is done by a centralised and specialised team of innovation experts.

### *Externally closed*

Again the two cases which seemed to be more externally closed than the other cases were LTech and Pharma. Interestingly, while LTech were involved in working in R&D consortia and having openness within their firm boundaries, the customer does not seem to feature in their open innovation activities. The following quote highlights something which could be at the root of external closed-ness, the fact that they are a 'conservative' firm:

*“So it usually works that we hardly ever do customer driven development. We sometimes do and it’s paid customer development and other parts of the firm do that. We have not done so much of that, we tend to know about a market and know the direction that that market is going in and produce a technology specifically for it. Often we follow so we’re a kind of a technology route and the market already defined. We’re quite conservative as a company.”* (Engineering Manager, LTech)

This shows that their technology development is pull-based demand but based on how a market is developing. This quote implies that their development is all based on market intelligence and not on what specific customers are requiring from the firm. Surprisingly, this seems to be in contrast to the involvement in the EU project which is concerned with more emergent technology development.

In the Pharma case they are extremely concerned about what information goes out into the public domain with regard to their product and technologies, in fact it was noted during the interviews that the interviewees were being careful not to disclose anything to the research team. This is exemplified by the following quote from the R&D Director:

*“We have to be very careful, don’t talk about it outside of the building, don’t present it at conferences, don’t talk about it in the pub. A lot of the guys here have academic colleagues, “Please don’t discuss it with your academic friends until we get it tied down.” Here, we don’t have... maybe we have 12 patents or something in the last 10 years, not a huge number but a fair amount.”* (R&D Director, Pharma)

This quote shows that IP protection, via patents, is hugely important for this firm. Remarkably, discussion with academic colleagues is discouraged by the R&D Director, where it is often noted that discussions with experts can often trigger further ideas and refine existing ideas. It is tempting to think that this might be hindering the innovative potential within the Pharma case, but we do not have evidence to support this claim.

Sydow et al. (2016) discuss why some firms might be externally closed due to IP issues or to the maturity of technology, in the Pharma case their technology is relatively mature for their industry and the firm culture is also one of IP protection, this might be a potential explanation for the closed-ness we have uncovered.

### **External knowledge**

#### *External sources of innovation*

One of the key themes that came from our data analysis was the use or sourcing of external knowledge i.e. the outside-in approach to open innovation. In our GMachine case they were very honest about how they approach innovation, they are employing relatively mature technology i.e. machining processes, and they say that they do not really need to be innovative as they buy that in from their external suppliers. The Managing Director demonstrated this in the following quote:

*“Well, we rely on the machine manufacturers to be innovative and then we take advantage of that innovation by investing in that equipment. On a slightly different level, we’ve also been quite innovative, I feel, in the work that we’ve done with SMAS. To me, that feels innovative. I know other people are doing it, but we’ve certainly changed the appearance of the business and our ways of working in a way that I wouldn’t have believed was possible. So there’s a degree of innovation there and more recently we’ve installed this MRP system. Again, lots of people have got MRP systems, but to me, to us, that’s new and, to a degree, it’s innovative. For our business, anyway, it is.”* (Managing Director, GMachine)

This quote seems to show GMachine having a strong reliance on external partners to help them stay innovative in their context. The maturity of the technology involved in this case is mature and this seems to be in contrast with what Sydow et al. (2015) say about technology maturity being a barrier for open innovation. It could be due to some idiosyncrasies within this case and this is something that will need to be explored in further research. The external innovation sourcing continuum (Nambisan and Sawhney, 2007) explains the trade-offs between ‘risk and reach’ with ‘speed and cost’ as to why some companies buy-in innovation and it could be that GMachine are risk adverse and so do not want any of the risks and costs associated with developing their own manufacturing technologies.

#### *External knowledge sourcing*

A theme which is related to open innovation in closed networks but is more concerned with where knowledge comes from and how this gets into the innovation process. In our case GGen, they are adopting an outside-in knowledge sourcing model. This is essentially where they collect information from their external environment and that is getting fed into the engineering process. The Sales Manager illustrates this with the following quote:

*“Sales and Marketing are now going to Engineering with ideas, rather than the opposite way around”.* (Sales Manager, GGen)

What this quote characterises is the changing dynamic from a technology push model to a pull model where the sales and marketing are making sure ideas from the external environment are making their way to the engineering team. So this type of openness is down to being open to new information from external sources not directly working with the customer but sales and marketing acting as a conduit to the customer. This is also true in GGen with the information that service engineers collect from the customer:

*“The service engineers are always out, obviously, doing what they’re doing, feeding that information back, and even with the sales people when they’re talking to customers obviously, they are getting information back as well”.* (R&D Director, GGen)

There seems to be some firms that use customers as a source of knowledge to develop products and product-service bundles in order to build relationships with their customers. It is interesting that we have two distinct cases where the information from the customers is treated very differently. In GGen customer information is highly important to the development of the product whereas in LTech the customer requirements and customer driven development is actually dismissed as being a risky strategy to developing innovation. There is contrasting views in the theory around this and the famous Henry Ford quote about him asking is customers what they want would have resulted in faster horses and not the motor car, show there is a risk aligning technology development to what the customer wants.

### **Clusters**

While all our cases were based within the relatively small geographical region of Scotland, only one firm talked about geographical clusters of customers and suppliers that all work together to undertake work and help each other out with business. Again our mature technology firm GMachine seemed to be more closely linked to their local supply chain, this is illustrate in the quote by the Sales and Marketing Director:

*“We’ve all got our own wee niche areas and we do compete with certain of these guys in certain areas, but quite often there’s enough work for everybody and we help each other out a bit. There’s a company, near, and we swap work back and forward with them quite a lot. Quite a lot of companies are our customers and suppliers as well”.*  
(Sales and Marketing Director, GMachine)

This quote demonstrates that in this in fact could be defined as a geographical clique (Lerch et al., 2006) rather than a cluster, since cluster implies a much more formalised structure. In our case, work flows between small numbers of manufacturers who all help each other. Thus at this point competition meets co-operation, from the interviews it would seem that these cliques are held together and managed due to a social network focus and a series of unwritten rules. This dynamic might be fragile and contingent on the amount of work available, as at this point the Sales and Marketing Director says there is enough work for everybody, the dynamic of the clique may change if there is less work available for the network.

### **Conclusions**

This research aimed to examine the concept of open innovation and understand if it occurs and how it occurs within the High Value Manufacturing (HVM) context. From our analysis it would seem that open innovation does occur in the HVM phenomenon. The findings suggest that many different ‘modes’ and types of innovation take place within the HVM context. Open innovation is witnessed more commonly from an ‘outside in’ perspective i.e. firms draw knowledge or technology from external sources into their internal innovation process. In value networks where retaining intellectual property rights are important there appears to be a lack of appetite for an open model of innovation. Our data also highlights the importance of the maturity of technology, i.e. has it become mature enough to be considered a platform within the value network, and the link to participating in an open innovation mode of creation and development. From our initial analysis it would seem the more mature the technology the more open firms are with their innovation process, this is in contrast to extant thinking in this area.

### *Future research*

This research has adopted single firms as a starting point and focus for the data collection, in line with our current thinking regarding HVM as a phenomenon that transcends firms as may reside within a network of firms, we will revise this aspect of our methodology in future research. This means that the focus of our analysis will be the network rather than any specific firm within that network.

The research presented in this paper is tentative analysis of a larger dataset and the analysis undertaken here could be further refined and developed to understand if the themes interlink and relate to one another. The initial findings seem to suggest that some of the themes are becoming interrelated such as the model of open innovation and the firms’ attitudes to sourcing external knowledge.

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