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Formation of Demand-Driven Collaborations between Suppliers in Industry 4.0 Production Networks

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Abstract
Trends for rapidly changing demands across the supply chains of manufacturing companies have resulted in increased collaboration activities involving companies of all sizes, from small to medium-sized enterprises (SMEs) to large OEMs. Industry 4.0 puts forward expectations that these collaborations are formed rapidly to respond to fast changing market needs and small lot sizes. Current information technologies can support such short-term, demand-driven collaborations to utilize excess capacities and quickly respond to existing business opportunities, yet a number of concerns still impede such collaborations. To explore the factors behind the up-take of demand-driven collaborations, we have surveyed a sample of companies from a major European association of aerospace suppliers. Our analysis reveals that competitive pressures, switching costs, information asymmetry, privacy, and path dependencies prevent the uptake of demand-driven collaborations. We use thematic analysis of collected responses to identify existing collaboration barriers throughout the virtual enterprise life-cycle and derive recommendations as to how to address these barriers and support such collaborations. The research findings discussed in this paper can be applied by OEMs developing manufacturing strategies in Industry 4.0 scenarios.

Keywords: Industry 4.0, Collaboration networks, Virtual organizations.

1. Introduction

Starting from the 80s, companies developed new manufacturing strategies to rebalance resources utilisation in order to better compete in their markets, and soon after 2000s many of them already reduced their costs as much as it was practically possible (Simchi-Levi et al. 2008). In particular, broad adoption of Lean Manufacturing principles has favoured tight relationships between Original Equipment Manufacturers (OEMs) and suppliers because of shorter lead-times, economies of scale and increased trust between supply chain members (Shah and Ward 2007, Heymans 2015, Brettel et al. 2014). However, maintaining such close ties can be challenging for many suppliers given a highly dynamic demand pattern observed nowadays on many product markets. Indeed, fluctuation of customer orders places a heavy burden on small and medium-sized suppliers due to underutilised capacity on the one hand and overhead costs, on the other. This goes contrary to the prevailing trend of reducing operational costs in order to improve competitiveness (Simchi-Levi et al. 2008).

A promising approach to cost optimisation is establishing collaborative 'digital' marketplaces where excess capacity can be shared among participating suppliers. Such a marketplace would offer supply chain members a capability of decomposing engineering, manufacturing and service requirements into smaller constituents, matching these with suppliers' capabilities and inviting tenders from matching suppliers. Moreover, production capabilities of several firms can be consolidated using standardised collaboration rules, intra-organisational process composition and data interfaces — to form a larger entity and apply for larger business opportunities (Hosking et al. 2008). In this way, excess demand from OEMs can be covered by virtual enterprises formed by second-tier suppliers within a reasonably short time period (Cisneros-Cabrera et al. 2017).

This short-term, demand-driven collaboration is aligned with recent trends associated with the term Industry 4.0, and also related to terminology such as Industrial Internet, Advanced Manufacturing and Smart Factory and Factories of the Future (Waslo et al. 2017, Weyer et al. 2015). Despite a number of expected benefits, SME participation in Industry 4.0 supply chains is currently facing a number of challenges, including perceived costs, risks, loss of flexibility and weakening of strategic independence (Smit et al. 2016).

Gaining insights into the factors impeding SME participation in such Industry 4.0 collaborations and developing a sound theoretical basis for their up-take is therefore essential for understanding and successful deployment of Industry 4.0 practices. Against this background, the present study aims to contribute to the research knowledge base by (i) revealing barriers and benefits of collaboration between SMEs and OEMs in the context of Industry 4.0, and (ii) proposing measures for overcoming the barriers and realising the benefits. The study is based on empirical data collected via semi-structured interviews with a sample of companies from a major European association of aerospace suppliers. By conducting the thematic analysis of collected data, we map the perceived barriers and benefits to the distinct stages in the formation of an Industry 4.0 virtual enterprise. Our analysis reveals that competitive pressures, switching costs, information asymmetry and privacy, and path dependencies prevent the up-take of opportunity-driven collaborations in Industry 4.0 and hamper the main benefits of Industry 4.0: productivity gains and revenue growth. We also articulate key performance indicators to gauge recommendation adoption practices.

The paper is organised as follows. Section 2 defines main notions and elaborates on the insights from academia and industry. Section 3 explains the methodology of the study, while Section 4 reports its key findings. Section 5 draws recommendations and concludes.

2. Literature Review

2.1 Digital Economy and Industry 4.0. Information and communication technologies have recently made significant inroads into societies all over the world, which has markedly influenced the way in which governments, businesses and individuals act. Commonly termed as *digitalisation*, the phenomenon underlying this transition is characterized by collecting, processing and exchanging information in digital form, which ultimately makes it easier to connect businesses and people, access and exchange information, as well as convert it to useable knowledge (Rappitsch 2017, Täuscher 2016). This transition is changing existing business models and creating new marketplaces, shaping the economy to what is being commonly termed as *digital economy*, in which knowledge and networks begin to play a more prominent role than before (Ciocoiu 2011, Gromoff et al. 2012).

An essential concept of the digital economy, *Industry 4.0* represents a policy initiative aiming at digitalisation of production processes along the entire value chain by letting "computer-driven systems monitor physical processes, create a virtual copy of the physical world and make decentralised decisions based on self-organisation mechanisms" (Smit et al. 2016). This approach allows for real-time visibility and control of all processes while reducing human intervention, which promises flexibility and efficiency gains (Davies 2015). As process digitization further penetrates industrial value chains, it brings dramatic implications for costs, revenues, and business opportunities, resulting in significant changes to how products are designed, sourced, assembled and distributed.

Against this background, the manufacturing sector in the European Union is estimated to include more than two million companies and collectively involve more than thirty million jobs (Davies 2015). While Industry 4.0 has only begun to appear in supply chains, often missing sufficient penetration rates or order concentration (Rüßmann et al. 2017), there exist a number of further challenges for up-take and diffusion of Industry 4.0 — such as process and technology standardisation, seed corn investment, information privacy and security in digital ecosystems, availability of skilled labour, and legal issues relating to trans-national industrial processes and virtual enterprise governance (Davies 2015, Smit et al. 2016). Some of these challenges can be especially difficult for small and medium-sized enterprises due to the limited resources that they have at their disposal in comparison to large companies. Nevertheless, their ability to adapt to the changes happening in their supply chains is essential for success of Industry 4.0 initiatives (Smit et al. 2016).

2.2 Industry 4.0 and Supply Chain Management. Digitalisation of production and logistics is widely claimed to provide a number of significant advantages to supply chain management in the Industry 4.0 paradigm. We can divide argumentation in the literature into the following propositions. First, digitalisation helps supply chains to better meet *market-related requirements* by ensuring a more reliable quality control and lead-time promising (Hofmann and Bick 2015, Müller et al. 2017), facilitating product customisation, tracing and tracking (Weyer et al. 2015, Kagermann 2015, Khan and Turowski 2016, Ivanov et al. 2017, Li 2017, Hofmann and Rüsch 2017), and increasing responsiveness by driving down manufacturing lot sizes (Chandra and Kumar 2000). These benefits are instrumental in reducing inventory levels and, eventually, cost while improving customer service (Lee et al. 2015). Second, it helps supply chains to become more *resilient* to internal and external disruptions by using data analytics for predictive maintenance and forecasting (Prajogo and Olhager 2012) as well as automated reaction to disruptions and problem resolution using cyber-physical systems (Ivanov 2018). Third, it helps supply chains to become more *sustainable* by means of better monitoring and involvement of local supply base (Müller et al. 2017).

This debate is, however, not entirely new to supply chain research. To date, a large body of supply chain and operations management literature has studied benefits of deploying new information and communication technologies in supply chains. Specifically, significant attention has been devoted to understanding benefits of gaining better *visibility* into shelf inventories using Radio Frequency Identification (RFID), which helps to improve inventory management and supply chain coordination (Lee and Özer 2007, Rekik et al. 2008, Heese 2007). Recent work has also addressed a combined use of RFID and temperature sensors for better controlling expiration of perishable inventory (Ketzenberg et al. 2015, Gaukler et al. 2017). A further stream of work has studied benefits of gaining visibility into the upstream channel by means of RFID and other technologies such as GPS — that can track order progress and thus enable a better inventory control and production scheduling (Gaukler et al. 2008, Chew et al. 2013, Mogre et al. 2014). Production scheduling and lead-time quotation have further been studied in settings assuming improved shop-floor process visibility (Chongwatpol and Sharda 2013, Kaman et al. 2013). On the distribution side, research has explored benefits stemming from visibility into the downstream channel (Pei and Klabjan 2010), inventory and information sharing via mobile communication (Pishchulov and Richter 2009), and access to real-time travel and traffic data in the transportation (Okhrin and Richter 2009). Several studies addressed supply chain *efficiency* gains from RFID due to automation (Lee and Lee 2010, Ustundag and Tanyas 2009) and partner collaboration (Sari 2010).

More recent research work shows a further convergence with the Industry 4.0 paradigm. For example, Guo et al. (2009) design and evaluate an RFID-based decision support system for production monitoring and scheduling in a distributed environment, which involves real-time data capture and remote scheduling. Reaidy et al. (2015) propose an RFID-based collaborative warehousing approach that allows several manufacturing companies to share their warehouse and transportation capacities in a distribution channel, in a dynamic and decentralized way, involving a multi-agent system design with competition and cooperation between automated, intelligent agents that represent physical pallets and various resources in the channel. Capacity pooling implemented by this approach allows the companies to better respond to demand fluctuations, reducing the costs and improving service (Reaidy et al. 2015, see also Pishchulov and Richter 2009). Reaidy et al. (2015) point to a number of challenges that are likely to impede adoption of their approach in practice — namely different technology standards, return on investment, trust, and performance guarantees.

The topic of our work is closely related with the latter study. Similar to Reaidy et al. (2015), we address dynamic, demand-driven collaborations involving capacity sharing, which helps companies to better absorb demand and supply variability. Differently from their study, we focus on companies' engineering and manufacturing capacities, and intend to explore the perceived benefits and impediments for formation of such collaborations, as well as derive recommendations for potential actions to mitigate barriers. In so doing, we particularly focus on potential collaborations between SME suppliers.

2.3 Demand-driven Collaboration. In the context of supply chain management, the term *collaboration* typically means transformation of conventional buyer–supplier relationships into partnerships within a network, facilitating joint product design and deployment of integrated logistics (Ross et al. 1996). In the present work, we define *supplier collaboration* as a commonly beneficial and mutually profitable development of relationships between suppliers for fulfilling a business opportunity, which they will more likely fulfil together through a virtual collaborative enterprise rather than competing independently to fulfil the opportunity (Chinn 2013). Using collaboration, SME suppliers can exploit existing business opportunities in various industries, utilise their excess capacities, thus increasing product availability and reduce costs (Galbraith 1995, Mehandjiev et al. 2008, Gromoff et al. 2012).

The present work addresses a particular form of supplier collaboration, which we call *short-term* or *demand-driven.* This kind of collaboration is typically initiated by a leading supplier in response to an emerging business opportunity. Such collaboration must not lead to creation of a new legal entity; instead, the participating companies are forming an *Instant Virtual Enterprise* (Mehandjiev et al. 2008), see Figure 2a, a concept fully in tune with the ideas of *Industry 4.0*. While technological opportunities indeed arise to network supplier shop-floors via cyber-physical systems and ensure process transparency for OEMs (Gilchrist 2016), a number of well-known barriers typically impede such collaborations (Liu et al. 2009, Niehaves and Plattfaut 2011), such as lack of trust between the parties (e.g. with regard to tracking) (de Vrieze and Xu 2016) and vulnerability of networks to cyber-attacks.

3. Methodology

3.1 Research Approach. In order to develop understanding of the barriers for Opportunity-driven collaborations in Industry 4.0, we adopt a qualitative research approach, tuned to the needs of the initial exploratory stage "when there is incomplete understanding of a particular phenomenon" (Burton et al. 2017). In particular we employ the case study method (Yin 2013) for gaining insight into the emergence of these barriers in industry practice. Figure 1 overviews the research steps.

3.2 *Case Selection*. We collected data in partnership with a major Multinational Aerospace Corporation (MAC) that increasingly relies on its suppliers for bringing innovations. Indeed, suppliers are responsible for nearly 25% of patents in MAC. That is why the corporation implements several initiatives to better utilise the innovation potential of partner SMEs, especially with regard to timely management of delivery ramp-up and establishment of new aircraft programmes. Additionally, expansion of legacy programmes requires capacity expansion at the suppliers' side too, challenging the multi-tier supply chain to accommodate new innovative SMEs and SMEs with spare production capacities.

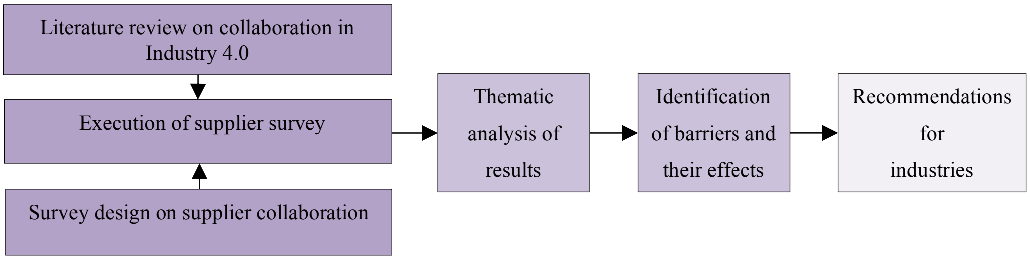

Figure 1. Overview of research steps.

Our second data collection partner is an Association of Aerospace SMEs (AAS), representing a wide spectrum of suppliers to aviation and space oriented service companies and mainly supplying MAC. AAS plans to expand its portfolio worldwide to cope with changes in supply chains and to collaborate with new partners for delivery of complex products and services.

Both parties need to align their strategies in order to attain their long-term goals. To take advantage of new market opportunities, AAS members require establishment of collaboration entities across firm boundaries. MAC has further to ensure nearshoring to local SMEs and to include these formations in their value chains. Both parties have to identify and tackle barriers that hamper collaboration and develop mechanisms for customer order monitoring through highly visible production chains and its end-product quality control.

3.3 Data analysis. Amongst approaches to analyse survey data, thematic analysis appears to be most suitable for exploring the meaning of unstructured data blocks. King and Horrocks (2010) define the word "theme" as follows: "*Themes are recurrent and distinctive features of participants' accounts, characterising particular perceptions and/or experiences, which the researcher sees as relevant to the research question*". Braun and Clarke (2006) explain "thematic analysis" as follows: "Thematic analysis is a method for identifying, analysing and reporting patterns (themes) within data". Thematic analysis is widely used, but there is no universally accepted method for conducting thematic analysis (Braun and Clarke 2006). We have followed the outline process illustrated in Table 2.

3.4 *Formalisation of demand-driven collaboration*. To formalise the notion of demand-driven collaboration in Industry 4.0 production networks into an existing business entity we use the concept of Instant Virtual Enterprise (IVE) (Grefen et al. 2010). This model represents an ideal structure to collate features of such collaboration to the stages of virtual enterprise formation and explains SMEs behaviour in predictable "breeding" environments, when they react to a new business opportunity (derived from tenders). Every tender launches a series of networking activities in the marketplace to find collaborators with available capabilities and surplus capacities. Once the new entity puts their bid and wins a tender, collaborative SMEs link their processes, infrastructures and further activate the virtual entity (Figure 2b).

3.5 *Case Summary*. We argue that there is a significant gap between theory and practice in identifying barriers to collaboration to Industry 4.0 in current OEM-SME relationships and to develop approaches towards addressing perceived barriers. For this purpose we analyse hands-on requirements: the 17 exploratory interviews that were guided by a semi-structured questionnaire with open questions designed to systematically explore existing collaboration experience of the respondents, the perceived benefits from collaborations, perceived barriers to collaboration, and recommendations for the impact of collaboration activities. In the questionnaires we included questions about supplier strategies, collaboration experience and problems faced. Examples of questions are listed below:

1. "What are the main barriers/problems for integration of your company in supply chains of your customers (e.g. OEM, 1st tier suppliers)?"
2. "What are the main impacts of the barriers/problems on your business?"
3. "What are your main activities to find partners and organisations for collaboration?"
4. "What are the main problems does your company have with collaboration of SME/organisations in networks?"
5. "Which information deficits regarding supply chain management (SCM) does your company have?"
6. "Which solutions of the mentioned problems in SCM can you recommend?"
7. "What are the top three benefits from participating in a SME network supported by information portals?"
8. "What are your comments or recommendations?"

The results were translated from German to English and processed by two members of our research team, who ensured periodic alignment of the resulting themes. Once the themes were formed, they were grouped into higher-level factors and mapped to the formation stages from Figure 2. The results of the mapping are presented in the Section 4.

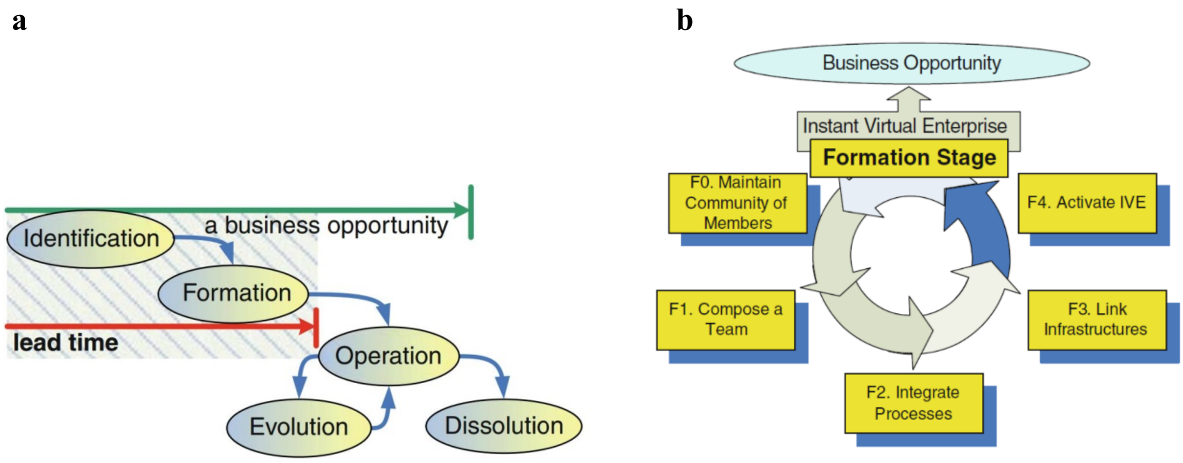

Figure 2. Life cycle of Instant Virtual Enterprise and its formation steps (Grefen et al. 2010).

4. Findings of the Study

In the present section, we discuss the findings of the study. The discussion follows the structure of the steps of Instant Virtual Enterprise formation (Grefen and Mehandjiev 2010), Figure 2b. Under each step we identify the barriers that faced by aerospace and automotive suppliers and ways in which these barriers manifest themselves in the selected case.

4.1 Step 1: "Identification of Business Opportunity (IBO)". In this step suppliers search for business opportunities that may arise once an OEM issues and disseminates a tender to the list of trusted tier-1 suppliers. If these suppliers have a lack of capacity or absence of a certain capability they manually decompose the tender into sub-tenders and look for someone to collaborate with towards addressing the capacity and capability gaps.

Barrier A: Costs of searching, processing and storing information. This barrier reduces tender visibility and collaboration chances between SMEs, as follows. The manual tender decomposition delivered by the 1st tier supplier (that often receives the major tenders due to its prominence as a 1st tier supplier) may not reach smaller SMEs, or the available work packages could be not attractive for them. Since SMEs are often early market entrants and lack bidding experience, they perceive many tender specifications as "vague", which reduces their chances to place an appropriate bid. SMEs miss guidance from more experienced collaborators with whom they may share risk of underutilisation and smoothen potential spikes of customer demand.

The question about the main problems for company's integration in supply chains identified evidences of barrier A: (A.1) Suppliers' miss calls for tenders due to the non-transparent tendering systems in place at present; (A.2) Information gaps due to vague specifications in tender descriptions; (A.3) Loss of information during communication between potential partners.

Barrier B: Unfit for tender (size, volume, schedule, finance requirements). Even if call for tenders are visible, SME collaboration chances still could be low. Barrier B hampers the availability of existing tenders for SMEs if supplier(s) cannot fulfil the formal requirements of OEM and/or higher tier suppliers. The lack of scalability and the lack of available resources are two popular problems, preventing SME suppliers from joining consortia to respond to fluctuating demands through collaborative capacity pooling. SMEs thus miss ad-hoc business opportunities.

The survey identified evidences of barrier B: (B.1) SMEs do not fulfil requirements of OEM and/or tier-1 suppliers to bid for tender; (B.2) SME's lack of manufacturing capacity for high-volume contract; (B.3) SMEs are able to sustain delivery volume due to discontinuous planning at OEM.

Barrier C: Path dependency. This barrier hampers change management activities in inter-organisational networks for conservative and ultra-conservative managed companies. The "lock-in" effect exists could be risky, since suppliers may lose independence having their manufacturer integrating backwards.

The survey identified the evidence of barrier C: (C.1) OEM opens Call for tenders only for tier-1 suppliers; (C.2) OEM demand ramp-up phases in delivery and long-term contracts; (C.3) Total focus on prices in the market.

Barrier D: Costs of negotiating. This barrier recalls Barrier A to the costs driven by information processing. In order to reduce the collaboration time one may consider installation of a common legal framework to simplify the alternative projects search and subscription to specialised digital platform and automated match making.

*The survey identified the evidence of barrier D: (*D.1) Physical networking takes too much time (months) to find alternative projects; (D.2) SME's inability to implement marketing initiatives capable to attract OEMs; (D.3) Differences in legal, tax and patent systems.

4.2 Step 2: Maintain Community of Members (MCM) – During this step, IVE suppliers form SME clusters for better coordination and capacity pooling.

Barrier E: Information asymmetry. This barrier negatively affects business scenarios where a particular supplier is more informed about call for tender details than other supply chain players. All participants have to be certain that decomposition of tenders to business opportunities is transparent; Tender match making considers suppliers' reputation as one of key criteria, in line with quality, business ethics and production criteria.

The survey identified the evidence of barrier E: (E.1) OEM/SME's lack of knowledge regarding collaboration in networks and Industry 4.0, (E.2) SME's inability to prove/verify its market reputation, (E.3) OEM's inability to share risks with the existing network partners

4.3 Step 3: Compose a Team (CT) – Once business opportunity appears, suppliers disclose their capacities and negotiate to form a team that can fulfil the OEMs tender.

Barrier F: Opportunism. This barrier considers the damage to collaborations arising out of self-interested behaviour, giving rise to need for resource-consuming secondary activities such as juridical, safety, and compliance validation activities.

The survey identified the evidence of barrier G: (G.1) Market is occupied by SMEs that try to get as much out of a collaboration as possible without providing anything "in exchange"; (G.2). Lack of trust between OEM and Suppliers, espionage, no partner reliability, complex qualification checks, (G.3). Requesting expensive certifications: NADCAP, GRAMS, environment (ISO 9100, 16949), (G.4) Too complex accreditation processes/ (G.5). Overprotection of property rights, SMEs insist to have their own contracts with the OEM, OEM dismisses the interests of domestic suppliers.

4.4 Step 4: Integrate Processes (IP) – The inter-organisational processes have to be steered towards the common goal, for this purpose companies align business plans and agree on data sharing policies.

Barrier H: Information asymmetry. This barrier negatively affects business scenarios where one supplier is more informed than another. In this case we cannot assure transparency in tender decomposition. Once resolved SMEs might apply collaborative workflow and real-time task tracking updates including change requests in real-time.

The survey identified the evidence of barrier H: (H.1) Integration of supply chain companies is challenging because of different business cultures worldwide; (H.2) Various Data protection policies/ Information privacy of suppliers; (H.3) Complex change management systems: short-term notice about changes in communication structures between OEM and tier-1 suppliers; (H.4) Knowledge gap in fulfilling requirements regarding processes and knowhow; (H.5) Time-consuming calibration because of missing knowledge on operating devices of customers.

4.5 Step 5: Link Infrastructures (LI) – The corporate IT infrastructures have to be seamlessly integrated to function as one team. For this purpose companies agree on data sharing practices.

Barrier I: Missing Intellectual Property & Information Privacy standards. This barrier hampers sharing of infrastructure costs (data centres, and spaces); development of unified data transfer standards and integration of shop-floor processes.

*The survey identified the evidence of barrier I: (*I.1) Restriction to direct connections between OEM and supplier: insufficient pool rooms with direct IT-interface to the OEM-systems; (I.2.) Potential for optimization in information flows and communication for structured data exchange; (I.3) Proprietary IT-systems without adequate standards for data transfer; (I.4) Varity of IT-systems impede integration of member of supply chain companies worldwide.

4.6 Step 6: Activate IVE (IVE) – The activation of IVE includes the official start of business opportunity fulfilment.

Barrier J: Costs of coordinating production projects. This barrier hampers common communication standards development and collaborative problem assessment and fixing.
The survey identified the evidence of barrier J: (J.1) Missing standards and interfaces in communication; (J.2) Quick fixes without proper analysis due to late customers contact; (J.3.) OEM requests testing too late and create big deadline pressure.

5. Initial Recommendations to Support Collaboration by Addressing Barriers

Integration in virtual companies offers the advantage of highly coordinated supply chain that has traditionally come through vertical integration. Our analysis reveals that competitive pressures, switching costs, information asymmetry and privacy, and path dependencies prevent the up-take of demand-driven collaborations in Industry 4.0 that hamper achieving the main benefits of Industry 4.0: productivity gains, revenue growth (Smit et al. 2016). Following the analysis of the barriers, we present a set of initial recommendations to address these barriers which can help support collaborations in Industry 4.0 supply chains (list below). An extended motivation of items in the list will appear in the full article.

1. Define and apply explicit and common *collaboration rules and procurement conditions,* thus addressing barriers A.1-A.3.
2. Develop collaborative business culture in SMEs to support *collaborative tendering* and address barriers B.1-B.3.
3. Introduce *cross-industrial B2B e-marketplaces* for Industry 4.0 production chains (tender preparation, supplier inter-organisational process management functions), in response to barrier A.1. These platforms could offer the following services to address further specific concerns:
   a. *Tender decomposition service* to eliminate industrial "asset specificity" of tender-parts, make them available for smaller sized firms and cross-industrial SMEs (B1-3);
   b. *Coordination service* to support *SMEs collaborating on a (sub-)tender (A3, D1-2);*
   c. *Matchmaking service* between sub-tenders and suppliers. This will require formalising supplier's manufacturing capacities and qualifications (C1, G3).
   d. The platform can help address barriers E.2, G2, H1-H5 by supporting long-term supplier *reputation tracing service.* This may involve *selective shop-floor monitoring* which would require liberalising corporate data protection policies.

6. Conclusions

In this paper we identify a number of barriers to collaboration between SMEs when these participate in the dynamic supply networks envisioned by the Industry 4.0 proponents. These barriers are analysed using the lifecycle stages of virtual enterprise formation (Grefen et al. 2010*)* in Section 4 whilst Section 5 offers a number of recommendations to erode some of these barriers.

For instance, the *Identification of Business opportunity* stage requires the introduction of an e-marketplace platform supporting SMEs in ad-hoc bidding to address incoming business opportunities. This digital platform would offer services for specialised tender allocation, decomposition and matching with registered SMEs profiles. Likewise, the *Maintain Community phase* requires collaborative business cultures, while *Integrate Processes* and *Linking Infrastructures* – liberalised data protection policies.

Our findings develop the state of art in the literature pertaining to factors supporting Industry 4.0-style collaborations by linking theoretical models to current perceptions and using these to analyse barriers and offer supporting remedies.

In our full paper we will extend the discourse of this preprint to provide an expanded explanation of the barriers to formation of Industry 4.0 network and an extended motivation of recommendations, including targeted advice to OEMs and Tier 1 suppliers regarding possible transformations of their sourcing strategies.

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