Building resilience and innovation through intelligent diverse supplier engagement

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Abstract: This paper reports the main findings from a design science research project that sets out to explore and understand the need for a more scientific and democratised process for preselecting, vetting, and engaging start-up and SME suppliers in a manufacturing environment. The project, using aerospace manufacturing as a test case will investigate the feasibility of using artificially intelligent web-scraping, third-party APIs, and distributed ledger technologies (DLT) to provide a localised and highly automated manufacturing marketplace. This paper's findings lend insight into emerging digital platform engagements between participating supply chain actors in open innovation environments.

Keywords: open innovation, supply chain resilience, diversification, supplier management, distributed ledger technology/blockchain, artificial intelligence

1. INTRODUCTION

Supply chains operate in an increasing volatile world with uncertainties and disruptions. These disruptions include, for instance, changing customer preferences, competitors' activities, unforeseen incidents (for example, the recent Suez Canal blockage in March 2021), geopolitical movements (such as the US-China trade war and Brexit), natural disasters (e.g., the 2011 Tohoku earthquake and tsunami) and the current Covid-19 pandemic (Ivanov and Dolgui, 2020). Those uncertainties and disruptions expose many hidden supply chain vulnerabilities (Sheffi and Rice, 2005; Wagner and Neshat, 2012). One of the major vulnerabilities is the over-reliance on sole suppliers for critical components and parts. Another major vulnerability is the complexities arising from lengthy global supply chains and the process of disengagement for down-stream suppliers due to the time spent on supplier onboarding. These drive the paradigm shift from global supply chains to more local and regional-based supply chains. As a result, there is a great need for organisations to build a diverse, resilient, and responsive supplier base (Bateman et al., 2020).

Meanwhile the success of a business has more to do with its supply chain than the individual organisation, and the role of a business has shifted from a producer of goods and services to a coordinator of value networks and ecosystems. Therefore, sourcing the best suppliers can bring real competitive advantages to a business, whereas failures in supplier selection can have high operational and financial consequences to a point of jeopardising the survival of the business. In particular, start-ups and SMEs provide a 'dynamic complementarity' through flexibility and responsiveness to new market requirements and technological opportunities in ways larger firms cannot. Increasingly incumbents seek to leverage the agility and expertise of SMEs in niche areas to improve their own products and services, enter into new markets and/or provide greater customer experience. This phenomenon is known as 'open innovation' (Chesbrough, 2003). Supplier diversity is also driven by the rising public, investor and government expectations on incumbents of environmental, social and governance inclusion, diversity and equity agendas.

However, effectively engaging with a large number of SMEs poses great challenges to larger firms. Hunting for new suppliers is a daunting, manual process. A recent McKinsey study identifies that on average, it takes about three months to complete a single supplier search, with a sourcing professional logging more than 40 hours of work to find a few dozen suppliers out of many thousands (Baptista et al., 2021). Large firms also need to make sure that required suppliers to adhere to social and ecological standards in order to mitigate their supply chain risks while protecting sensitive commercial information such as intellectual property. The associated risk around intellectual property provides a barrier to engaging SMEs in an open (external) innovation environment due to loss of their valuable, novel developments, and the need for larger enterprises to release large swathes of data and information to solve their most challenging business problems.

Companies wishing to engage in OI can now implement innovative self-governance thanks to the transparent and decentralized nature of Distributed Ledger Technologies (DLT) / blockchain. Every interaction is recorded using cryptographic methods and publicly available on a distributed

ledger, a set of indisputable rules can be independently and automatically enforced through smart contracts linking specific interactions to transactions (Rivière, 2018).

Blockchain imparts intrinsic confidence in its data due to its tamper-proof characteristics and ability to demonstrate data authenticity. This means that IP remains verifiable with all of its associated data, such as developer information, CAD files, material specifications and so on (Maiti and Shilpa, 2020; Papakostas et al., 2019). Centralized DLT can vastly improve the effectiveness of multi-agent IP (patent) management, speed up the innovation process and foster easy verification and transparent distribution of manufacturing IP (Rivière, 2018). Hence the main question our research seeks to address is as follows:

RQ: How might we empower large manufacturing organisations to diversify their supply chains whilst reducing the associated time, cost, and risk?

Our research aim is to explore this RQ through a case examination of a supply chain tech company's development of a supplier discovery platform protocol in collaboration with a large aerospace manufacturer.

2. RESEARCH BACKGROUND

2.1 Open innovation

Open Innovation (OI) is defined here as the processes that managers start when deciding when, how, with whom, with what purpose, and in what way should they cooperate with external partners OI has increasingly been accepted as a potential source of competitive advantage, enabling the use of external sources of innovation and external commercialization strategies. OI generally involves two or more actors that become part of a network of interconnected innovation actors, resources, activities, and institutions, connected by organizational and market relations referred to as the innovation ecosystem (Dedehayir et al., 2018; Greco et al., 2015; Holgersson et al., 2018; Rodríguez, 2014).

Increasingly incumbents seek out agility and expertise in niche areas to improve their products or services, enter new market segments, and/or improve their customers' experience. For example, Schneider Electronic is collaborating with over 700 SMEs and start-ups to bring innovations into its own supply chain. It offers a life cycle collaboration with its suppliers from concept, new product/solution development, go-to-market strategy to delivery (Schneider Electric Guidebook, 2019).

OI explains how firms rely on external technologies to augment their internal innovation development or how they tap into external partners to exploit internally developed technologies. In these collaborations, contracting (licensing) rather than integrating is viewed as the preferred approach when there is adequate capacity and a choice of sources (suppliers) (Holgersson et al., 2018). Relationships in OI and innovation ecosystems are seldom symmetrical, and the balance of power may shift over time, due to technological changes, strategic and business model changes (e.g., multiple tiering, open book pricing), or change in actors in the innovation ecosystem (Holgersson et al., 2018; Roy and Sivakumar, 2011; Skeete, 2019).

It is important to note here that there are specific linkages between OI practices and new product development (NPD), which is a multi-stage, multi-disciplinary process. However, NPD will be out of the scope of our research as we primarily focus on the interactions between large manufacturers with their suppliers in product, service, and solutions procurement.

2.2 Supplier Discovery and Selection

Supplier selection is considered by researchers and practitioners as one of the most important responsibilities of the purchasing function (Yang and Xu, 2004), as it can minimize the supply chain risks at the stage of the supplier onboarding (Akmaikin, 2020). Simply looking for vendors offering the lowest prices is no longer considered 'efficient sourcing'. Selection of suppliers is a multiple criteria decision (MCD) that includes both quantitative and qualitative criteria such as quality, price and delivery time, and socio-political factors such as regulations, policies, political instability and civil conflicts (de Boer et al., 2001; Lesisa et al., 2018; Yang and Xu, 2004). Quantitative criteria are measurable in solid dimensions (e.g. costs), but qualitative criteria are not so easily assessed as they may have interdependencies and contradictions with each other, which in turn increases the complexity of decision making (Jain et al., 2014). This form of risk management has become a key component of organizational strategy to ensure efficient management of operations and the mitigation of possible adverse outcomes (Lesisa et al., 2018).

This is important as competitive advantages in supply chain management (SCM) can be achieved by strategically collaborating with suppliers and service providers. The challenge lies however in selecting good suppliers that can maintain a continuous supply-relationship (Hong et al., 2005; Jain et al., 2014), as the success of a supply chain depends on the selection of good suppliers (Ng, 2008). The supplier selection process includes problem definition, formulation of criteria, pre-qualification and final evaluation (Gassmann and Bader, 2006). Pre-qualification is defined here as the process of reducing the set of 'all' suppliers to a smaller set of acceptable suppliers (Hong et al., 2005). Supplier selection in OI is especially crucial as SME suppliers have a large and direct impact on cost, quality, technology, speed, and responsiveness (Yoo, 2016).

Supplier pre-qualification is a critical step in the supplier selection process, where the objective is to screen out supply applicants that do not meet basic requirements to such a degree that any further detailed assessment of their applications would be unnecessary. It also aims to provide feedback information to an applicant about where it should improve in order to be a qualified supplier. The main purpose of supplier pre-qualification assessment includes the identification of strengths and weaknesses of an applicant, which could form a basis for subsequent detailed assessments and for creating action plans to address the weaknesses identified (Yang and Xu, 2004).

Some of the more popular supplier pre-qualification approaches include data envelope analysis (DEA), mathematical programming, AHP, case-based reasoning (CBR), ANP, fuzzy set theory, simple multi-attribute rating techniques (SMART), and genetic algorithm (GA). AHP has been integrated with other techniques, including artificial neural network (ANN), bi-negotiation, DEA, fuzzy set theory, goal programming (GP), grey relational analysis, and multi-objective programming. Regarding criteria selection, the most popular criterion in the reviewed literature is quality, followed by delivery, price/cost, manufacturing capability, service, management, technology, research and development, finance, flexibility, reputation, relationship, risk, and safety and environment (Jain et al., 2014).

More recently, data mining has been proposed as an approach for discovering hidden relationships among suppliers' pre-qualification data. Data mining has been found to be useful in many fields including medical, defense and crime detection, as this approach is highly capable in certain tasks such as classification, clustering, association rule discovery, sequence pattern discovery and regression (Jain et al., 2014).

3. RESEARCH METHEDOLOGY

This research adopts a participative research approach and is particularly informed by design science research (DSR) methodology. A typical design science approach follows the steps of problem identification, objective definition, design and development, final demonstration and evaluation (Holmström et al., 2009).

Funded by Innovate UK, academic researchers from the disciplines of computer science and supply chain work in collaboration with a supply chain tech company (hereafter as Case company) which specialises in bridging suppliers and buyers in OI procurement. The roles of academic researchers are not to solve the problem per se within a specific organizational context, but to generate knowledge that can be applied to the class of problem that the specific problem exemplifies – this type of research is termed as action DSR (Sein et al., 2011). One can refer to Wang et al. (2021) for an example action DSR research in the supply chain field.

Our case project focuses on an OI model - similar to procure-to-pay suites (Gartner, 2019) - where external actors participate in a corporation's innovation processes. This is a business model where supply-chain platform owners (a supply chain intermediary) attract clients (manufacturing assemblers) that publish a need (or "challenge") on the platform and then, a larger group of external innovators (suppliers) from the ecosystem, is invited to submit their solutions to it (Gawer and Cusumano, 2014). The type of need published may range from collecting bare ideas ("ideation") up to a specific solution leading to the creation of intellectual property rights (IPR) in a cooperative agreement (Gawer, 2014; Maicher et al., 2016).

The project consortium believes that an online platform that utilises the latest development in artificial intelligence (machine learning), big data analytics and DLT holds the key

answer to the problem identified (as discussed in Section 1). The project is positioned as a feasibility study and aims to develop a minimal viable product protocol that will allow larger firms to automatically search, sift, prequalify, and engage the start-ups and SMEs that will bring the required expertise and solutions to address its supply chain challenges. The project lasted six months and was divided into six work packages. Figure 1 summarises the logical flow between the work packages and the main outputs accordingly.
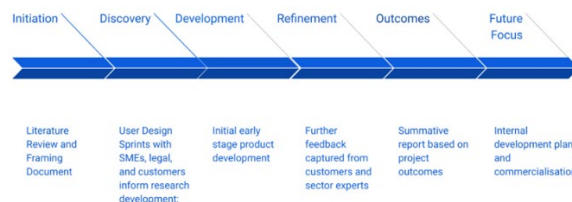

Figure 1: An overview of research stages and key outputs

4. FINDINGS

4.1 Initiation: state of art developments, gaps and new frontier opportunities

Figure 2 summarises the key themes identified from our literature review. One of the major interesting findings in terms of supplier selection and engagement and the related challenges and opportunities is that most of the academic and practice literature emphasise the importance of establishing a closer relationship between buyers and suppliers which will help supply chains to become more resilient. Supplier and buyer collaboration brings a number of well-known benefits for example, 1) developing innovative new products and services thus leading to revenue and profit growth for both parties; and 2), taking an integrated approach to supply chain optimisation by establishing the end-to-end supply chain visibility and through joint planning and execution (e.g. CPFR practices).

However, there is surprisingly little literature on how to identify and find the right suppliers (often from a vast global pool of suppliers) to engage with. Explicit efforts in exploring the intellectual property protection issues are equally scarce and are often discussed as part of supply chain risk management. Yet it is clearly evident that IP rights help firms to obtain and sustain competitive advantage and gain vertical power along the supply chain. IP management cannot be left to technology managers or corporate legal staff alone - it must be a matter of concern for functional and business-unit leaders as well as a corporation's most senior officer. These gaps identified validated the problem statement and the need for the feasibility study.

The dynamics of buyer–supplier R&D projects require both knowledge sharing and protection. Scholars seeking to resolve this dilemma have focused on collaboration governance (i.e., managing the buyer–supplier exchange relationship) through

both relational and contractual mechanisms. Our literature review exercise also identifies the use of DLT and AI as new frontiers which can take supplier engagement and collaboration to the next level. With AI enabled techniques/tools and utilising cloud platforms, supplier discovery can be greatly accelerated and simplified. This is of utmost importance given the rapid changing global economy and frequent supply chain disruptions.
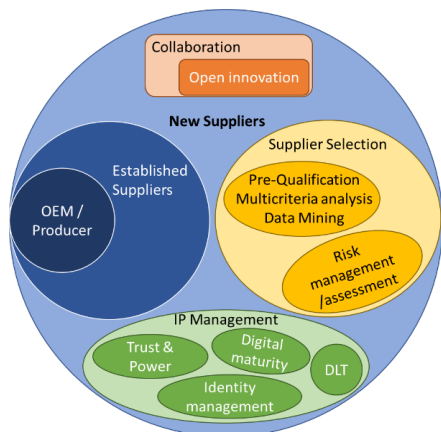

Figure 2: A visual summary of the literature findings – key themes

4.2 Sensemaking with SME Suppliers and Legal experts

Two workshops were held to gather insights: one with SMEs and one with legal experts. In addition, one-to-one interviews were also conducted with a major engineering firm. The key findings from the multiple stakeholders have helped to establish a robust understanding about how the proposed technical solution may address the multiple issues faced by both SMEs suppliers and large buyers with due consideration of the legal constraints.

For SMEs, they want simpler and relatively straight forward interactions with large firms and request a degree of transparency and trust to be built in the process. They also demand for the NDAs to reflect both parties' needs not just the large firms. For large buyers, they would like the digital solution to automate the currently highly manual processes, provide more insights about the suppliers' technological capability (esp. new product information) and maturity, and build the supplier feedback in the communication loop to allow the suppliers to challenge or enhance the existing tender/challenge specifications.

For legal advice gathered from the project partner company, data must be collected for a legitimate and legal purpose - caution should be taken with the scope and volume relating to personal data. Knowledge transfer/exchange between supplier and customer are enabled by an NDA, which should only be signed (and witnessed) by duly authorised persons. Those insights gathered further validated some assumptions and clearly defined the problem space and areas where the innovation efforts need to be invested.

4.3 Development of a Digital Platform Protocol

Inputs gathered from the literature review and workshops (as discussed in Section 4.1 and 4.2) serve as foundation to the technical team, and result in the development of the technical protocol. It contains two building blocks: a) innovation intelligence which allows the client companies to search, curate and invite the suppliers to a tender/challenge, and b) IP management which utilises the Ethereum blockchain service to allow the client companies to define IP statement, the interested suppliers to sign and commit to the agreement and then set the green light for both parties to progress to the next stage of collaboration. Following this, the supplier can view the complete challenge, and any associated "sensitive information" and begin to create and submit their ideas.

4.4 Refinement and Validation

Two workshops were organised: the first with a target client and a second with a wider industrial audience. The feedback from the target client confirms the potential economic benefits it brings to the company and would help to 'take the guesswork' out from the current practice. Valuable recommendations were provided which include some fine-tuning of the tool e.g., adding a filter function and source of a supplier investment. Other suggestions require more effort, for instance to develop a standard 'risk profile' of suppliers that considers multiple attributes and build an automatic connection to its existing supplier management system.

The open workshop asked 13 participants (from various sectors) to identify what are the main challenges of engaging new suppliers from their perspective. The time spent selecting suppliers from a global marketplace is identified as the top challenge, followed by risks around due diligence of suppliers and management of IP. Participants who showed keen interest to have further conversations with the case company. Participants have also asked several questions concerning GDPR issues, the data security issue in terms of using DLT and the platform itself.

4.5 Reflection and Evaluation

- Timeliness

This technological solution, albeit at its early stage of development, is timely. This is not just because Covid and a number of recent significant supply chain disruptions (ranging from the shortage of lorry drivers and energy, the rising of container prices, the ongoing trade wars between the US and China) have accelerated the need for supplier diversification and inclusion to remain resilient. It is also because there are great opportunities and value to unlock if large incumbents work in collaboration with suppliers. Ahuja et al. (2021) in their 2020 survey identified that 88 percent of respondents either have started, or plan to start, joint-innovation programs with their suppliers.

- Novelty

Technologies, if used in isolation, would not generate strategic value. AI has really reached its tipping point after six decades of development, while DLT is still at its infancy stages. The core innovation in this project lies in its combinative use of

both technologies while taking advantage of the vast amount of data out there (from a variety of proprietary, public-source, and commercial databases as well as online social media platforms). The DSI's technology understanding (about the realm of possibilities brought about by AI and DLT) merges well with the strategic insights about the opportunities arising from the existing supply chain practices. This is critical to allow the company to develop a compelling technology use case that solves a pertinent supply chain challenge.

- Value creation

For larger incumbents, the development of AI-based supplier discovery tool with blockchain-enabled IP management is fundamentally changing the speed at which it is possible to find the right suppliers, optimize a company's supply base while protecting the important commercial sensitive information and IP. Purchasing professionals now can identify the most suitable potential partners from millions of candidates in days (rather than months), giving them the tools to cope with today's rapidly changing economy. This need for speed will only increase and the companies that leverage emerging technology to respond will reap the rewards. This, ultimately, improves productivity, and builds their supply chain resilience and flexibility.

For SMEs, the AI-based data scrapping technique 'grabs' data about their businesses using both structured and unstructured data (e.g. social media) will make them more visible to potential clients. The automation also helps to ease the often-frustrating administrative burden and barriers when they try to engage with large customers. The blockchain element of the tool builds much-needed trust in the process. There will also be significant productivity savings on the legal advice, guidance, and execution of non-disclosure agreements by using an automated process. Though a word of caution here, such a tool should not add extra cost burden for SME suppliers. Otherwise, it may negatively impact its scale-up.

6. CONCLUSIONS

The research sets up to explore the answer to the RQ: *How might we empower large manufacturing organisations to diversify their supply chains whilst reducing the associated time, cost and risk?* Via a design science approach and in collaboration with a supply chain tech company, an innovative supplier discovery platform protocol was developed, demonstrating great potential to build supply diversity and innovation into the supply chain for responsiveness and resilience.

The deployment of this digital tool will likely to be a complex process. It is because it requires changes in mindset and behaviours, as well as new technological, relational and process configurations among multiple organisations. Therefore, a clear understanding of the requirements and issues across all participating supply chain actors are critical to the success of its deployment. This provides an important avenue for our future research. Future research should also address important questions such as - what would be the right revenue model one should design to capture the value created

by the platform? How should the value be appropriated among participants?

Finally, there is certainly more that could be done to further build and improve the current Minimum Viable Product (MVP), for example further investigation of consensus mechanism, the use of smart contract and tokenisation (to close the feedback loop) and blockchain analytics.

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