al. 2017). To cope with these changes, a more efficient and precise supply chain is needed. Through adaptation of new business process design, active operational controls can be controlled and improved through AI and automated systems at human competence levels (Klumpp 2018). For example, automated vehicles will be able to re-route based on real-time traffic conditions of an oncoming street which is not visible to human driver, production sequence can be re-scheduled instantly when delay of inbound supplies is detected at the production site, automated warehouse systems are able to release stock information from distant locations based on real-time information of end-customer sales or production demand. According to Klumpp (2018), there are three levels of human-artificial collaborations described hereunder.

- *AI competences*, are applications of AI in specific fields such as forecasting demand or automated navigation systems. These functions solely rely on human supervisions and controls.
- *AI decisions*, are applications of AI in providing suggested decisions on a limited area of actions. For example, guided cruise control for vehicles or route suggestions on navigation system. These functions will provide suggestions based on human supervisions of scope and information, and
- *AI autonomy*, are applications of AI in performing autonomous behaviors with human interactions. For example, driverless vehicles or factory bots. In these cases, humans take over a passive supervising.

The collaboration based on AI in business processes allows firms to make "better" decisions in avoiding waste and lowering supply chain risks.

4.3 SMART Supply-Chain Application Model

SSAM is the stage where firms collaborate with other firms which shares similar visions in SSCM. With SMART networking, members in the SSCM are able to incorporate information and materials through collaborative CPS and make cohesive decisions (Ivanov et al. 2016). Such system requires adaptation and reconfiguration of SMART factory or manufacturing to allow machines and products to interact with each other without human control. According to surveys conducted by PWC, 50 percent of German companies are gearing towards SMART networking and 20 percent of them are already involved with SMART factory or manufacturing (Ivanov et al. 2016). In addition, SSAM can be seen as an interaction in between supply chain collaboration, data sharing, integration and partnerships which ultimately leads to a possibility of process and product innovation.

4.3.1 Supply Chain Collaboration and Data Sharing

One of the key benefits of adopting technology and sharing data in the collaboration of supply chains is to eliminate waste while increasing agility of the supply chain. An end-to-end connectivity allow supply chain members to have a quicker response to market changes through configurable supply chain cloud network. According to Brettel et al. (2014), collaborative development and manufacturing environment is critical for SMEs with limited resources. Under a collaborative environment, data transparency would allow firms to gain access to an expended perceivable market opportunity with diversified risk. The importance and value of information for an effect SCM has been extensively highlighted in the literature and most notably in the area of data sharing (Wamba et al. 2015). According to Alicke et al. (2016), the impact of SSAM is expected to lower 30 percent of operational cost, 75 percent of lost sales and 75 percent of decrease in inventories. However, to allow such system to work efficiently, adaptation and reconfiguration of the existing structure are needed.

4.3.2 Supply Chain Integration and Partnership

The challenges for supply chain experts today are to determine how to integrate technology with the existing supply chain management and customer relationship management applications with the entire system. Digitally integrated supply chain functions such as predictive analytics in demand planning, closed-loop planning, automation of knowledge work, advance profit optimization a scenario planning would allow supply chain members to gain competitive edge through the process of planning. Other digitally integrated functions such as automation of warehousing, autonomous smart vehicles, human-machine interfaces, SMART logistics planning algorithms, reliable online order monitoring, real-time re-planning, real-time vender inventory monitoring and no-touch processing would also provide advantages through the process of physical flow and order management (Brettel el al. 2014; Alicke et al. 2016). To ensure the exchange of information, a uniformed standard for information transfer is to be applied throughout the supply chain.

According to Wang et al. (2016), three key features of integrations should be addressed in order to understand the relationships in between each supply chain members: horizontal integration through value networks, vertical integration and networked manufacturing systems, and end-to-end digital integration of engineering across the entire value chain.

- *Horizontal Integration.* Cooperation in between related-firms that stimulates value through inter-corporation horizonal integration. This would allow firms to form efficient eco-systems through information, finance and material flow.
- *Vertical Integration.* This is a self-organized system (SMART production, SMART manufacturing and SMART logistics) that allow reconfiguration through a firm's own physical and informational subsystems.
- *End-to-End Engineering Integration*. This is a continuous and consistent model which involves through a chain of activities such as customer requirement expression, product design and development, production planning, production engineering, production, service, maintenance, and recycling to create a product-centric value creation process.

To maintain a global competitive advantage, companies will have to focus on their core competencies while outsourcing other activities to collaborators in the network. According to Christopher (2000), the ability to leverage competencies of partnerships in order to respond to market need can lead to sustainable advantages. Therefore, the effort of integration and partnership along the supply chain eco-system may foster a trustful relationship which may lead to higher level of information-sharing across parties (Kache and Seuring 2017).

4.3.3 Process and Product Innovation

Through supply chain collaboration and integration under the platform of SSCM, higher utilization of information and communication technology allow products and production to be engineered digitally. Modular simulations and techniques allow firms to decentralize and alter production processes and thereby stimulate faster innovation of process and product (Brettel et al. 2014). According to Kache and Seuring (2017), the reduction of lead time in product design and prototyping through improved supply chain visibility, provides time benefit of increased data availability on the supply chain level, especially in regard in time compression of innovation cycles. Other than the benefit of time, the use of collaborative prototyping also allows supply chain members to save cost in research and development process and to accurately response to customers' specific demands (Tan et al. 2015). A schematic flow of SSAM is illustrated hereunder (Figure 4.1).

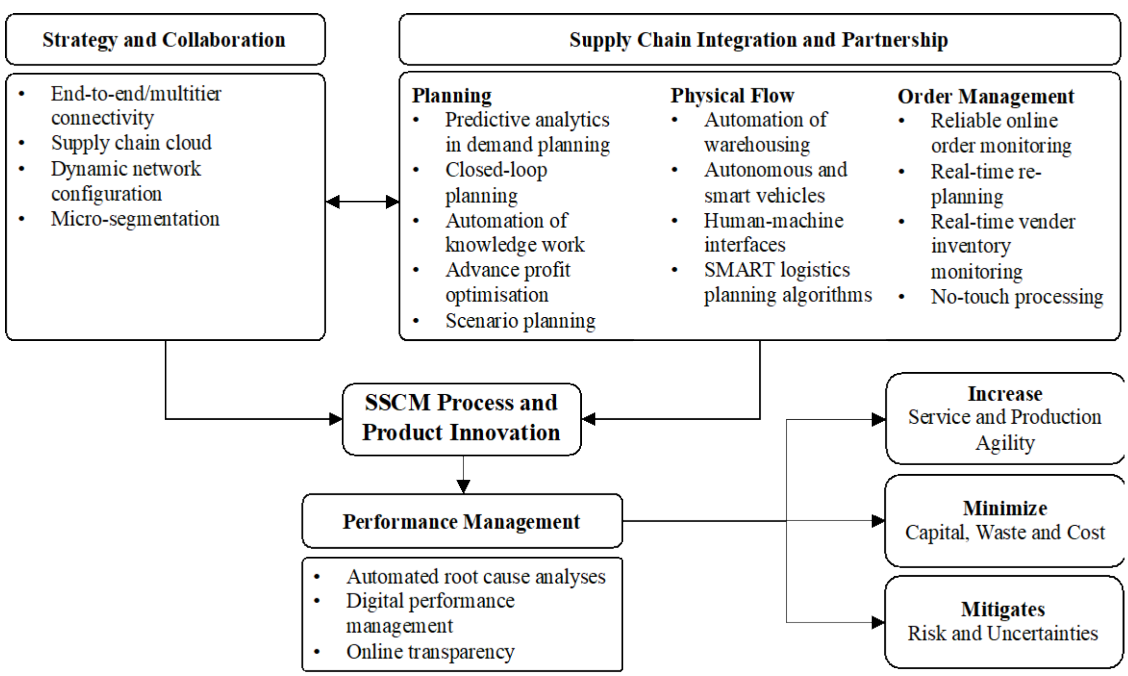

Figure 4.1: Schematic flow of SSAM

5. Integration of SSCM for SMEs

According to the proposed SSCM implementation model, three transitional phases are presented as LAM, IAM and SSAM. Each individual phase represents the level of information and technology integration in the firm and the performance benefits that are expected. With the IAM phase, SMEs would apply information technologies to support functional activities such as inventory management, order management and production management but under a CLSC environment. Some of the main reasons why SMEs would adopt technologies in their management practices would be cost, time, human error and competition (Wu et al. 2016). With the introduction of SMART factory and services, a high level of trust and acceptance in technology are to be built in order to elevate an overall supply chain performance. SMEs would need to empower their system to allow them to make operational decisions based on a self-aware AI system. This is often a very difficult task to comply due to lack of confidence and other disruptive factors such as dynamic business conditions, contestability of local market and rapid obsolescence of knowledge and skills (OECD 2017). Furthermore, the requirement of sharing information through the supply chain is often considered as a very sensitive due to the risk of information leakage (Kembro et al. 2017). Therefore, a certain period of adaptation is needed to resolve these barriers. Finally, through a period of adaptation and usage, SMEs can advance itself to SSAM phase where activities such as integrate sourcing, product and retailing process would further increase an overall supply chain performance. In this phase of SSCM implementation, SMEs would empower information technologies to make operational decisions. Instead of using human-to-machines interfaces, machine-to-machine (M2M) are relied on. This gives SMEs the ability access strategic resources which are critical for their competitiveness and allow rapid process and product innovations. The SSCM implementation model is presented hereunder (Figure 5.1).

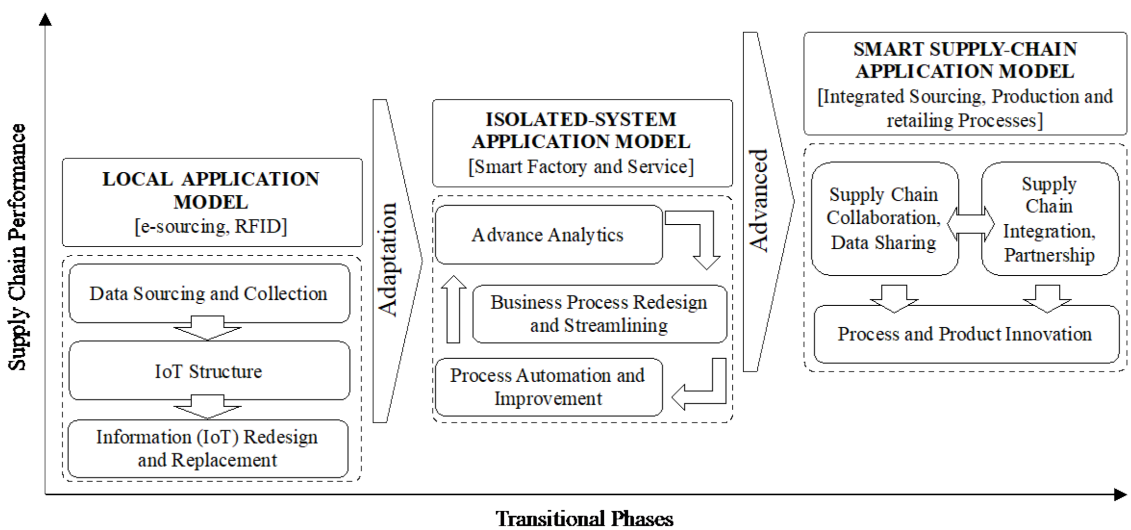

Figure 5.1: SSCM Implementation Model

6. Discussion

In this paper, we have presented the SSCM implementation model as a conceptual framework in identifying the transitional phases and requirements of SSCM for SMEs. Several key benefits of SSCM has been highlighted in this paper, which offers new opportunities allowing for SMEs to compete in the global market. However, according to OECD (2017), majority of SMEs have not been able to acquire the benefits of the technological transitions and are lagging behind in adopting these available technologies to their management practices. For example, in most developed countries over 75 percent of firms adopt enterprise resource planning (ERP) application to manage business information flow, while only 20 percent or less are used by SMEs. The transformation process of the SSCM for SMEs requires three key managerial enablers, namely: a clear definition, new capabilities and a supportive environment. The key technological enablers are integration of cloud manufacturing and IoT information infrastructure capabilities which supports real-time planning and execution of supply chain synchronization system (Qu et al. 2016). The lag of adaptation of SMEs is mainly due to lack of investment and knowledge assets, such as research and development, human resources, organization changes and process innovation (Wang et al. 2015; OECD 2017).

In light of this research, the contribution of this study is geared towards firms in realizing the benefits of adaptations to gain competitive edges. Due to the nature of SMEs, especially family enterprises, lack of appropriate corporate governance structure, inconsistency of decisions and business transfers may result in poor management practices. However, it has been proven that the recognition of IoT and CPS technologies allow firms to offer customers products with superior quality and competitive in price (Brettel et al. 2014). Therefore, realization of SSCM practices would enable SMEs to gain a better understanding of processes within the firm, the need of their customers and the overall business environment (Ivanov 2016; Wang et al. 2016; OECD 2017). Under the context of academic research, we have contributed to the emerging field of I4.0, supply chain management and SMEs and its supply chain relationships. Along with the highlighted phases of implementation, deliberation of new supply chain models is possible along with new introduction to digital value-chain. We have also conceptualized three distinct transitional phases of SSCM along with the relationship of their individual enablers. While there is voluminous research literature available on SCM, only a hand full of research indicates the applications of SSCM to SMEs. To consolidate the discussion threads, new possible research directions such as; IoT data analytics for SMEs, development of SSCM for SMEs, economic value of SSCM applications for SMEs and SSCM practices for SMEs is worth future investigations.

7. Future Research Suggestions

This paper is informative in nature. It is worth noting that only a handful of literature, mostly conference articles, are published over the past 5 years since the introduction of I4.0. However, the very prediction of I4.0 has created unique opportunities for researchers to investigate the endless possibilities of supply chain practices and its impact on the business environment. The SSCM implementation model offers a stringent perspective on the adopting of new information technologies, which could be recognized in a portion of the analyzed literature. Newly articulated dimensions of supply chain management would require innovative integration of different expertise and new business development strategies. The main implications for future research include a need for more work in theoretical issues of SSCM for SMEs and empirical research, such as case studies, to provide practical insights. Furthermore, it will be interesting to systematically compare the transitional phases and the situational enablers of SMEs in different industries or countries. Nevertheless, there is still a strong demand for future SSCM research activities in the context of SMEs.

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