CHALLENGES AND OPPORTUNITIES OF INDUSTRY 4.0 FOR LOGISTICS & SUPPLY CHAIN MANAGMENT

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ABSTRACT

Purpose: Around the world, traditional manufacutring industry is in the midst of a digital transformation that is accelerated by exponential growing technologies, commonly encapsulated by the term - "Industry 4.0". It encompasses a promise of a new industrial revolution—one that marries advanced manufacturing techniques with the Internet of Things (IoT) to create a digital manufacturing enterprise that is not only interconnected, but communicates, analyzes, and uses information to drive further intelligent action back in the physical world (Deloitte University Press, 2017). The ubiquitous connection of people, things and machines through networking across the "internet of things", services, data and people. Logistics and supply chain processes will have to transform and shaped in order to work seamlessly with these disruptive technologies that will create a seamless link between the virtual world and physical object in the real world (Hofmann & Rüsch, 2017). This study fills this gap through a conceptual research approach (Meredith, 1993) to provide a better understanding of this rather undiscovered topic. To this end, this study raises three key research questions: - (1) What are the potential benefits in adopting disruptive technologies in logistics and supply chain management (LSCM)? (2) How can organisations manage challenges in process transformations based on a lean perspective and (3) What are the relevant skillsets that the future of work will entails in LSCM?

Design/methodology/approach: Although Industry 4.0 and the relevant disruptive technologies have received a lot of attention recently in practitioner oriented articles, research in this area remains scarce. An exploratory research approach is employed as we aim to provide a holistic overview of the implications of Industry 4.0 in LSCM by addressing the prior research questions. The exploratory study involves an initial phase of narrowing down the relevant literature in Industry 4.0 and the context of LSCM. This was accomplished through an extensive desk research on extant literature and accompanied with multiple unstructured discussions within the research team of the authors and practitioners whose organisations and operations are involved in implementing change and transformations in their work processes.

Findings: In addressing the three research questions, this study first sets out the key challenges that logistics and supply chain companies face in digital transformation and the potential benefits from a successful adoption of exponential technologies. To aid companies in successfully manoeuvre the transformation processes brought about Industry 4.0, the paper focused on how companies can transform work processes using a systematic approach that is guided by the lean philosophy to enable real time integration of networking systems, supply chain transparency and optimisation. In particular, we make use of lean methodology to examine how basic principles and tools in lean can be integrated with the next generation of logistics and supply chains to bring about simplification in processes and operational complexity. In addition, this paper provides insights on the core skill sets that the manpower has to be equipped with in order for people to work seamlessly with technologies, automations and robotics in the same organisation.

Originality/Value: The findings from this study is expected to provide a deepened understanding on the impact of transformations that can be brought about by disruptive technologies.

Practical implications: Logistics practitioners and supply chain managers can make use of the findings to (1) make informed decisions in streamlining LSCM processes by adopting lean as an established management approach, and (2) equip the existing workforce with the necessary skill sets so as to support the organisation in reaping the potential of disruptive technologies.

Keywords: Disruptive Technologies, Logistics and Supply Chains, Skills sets, Lean, Conceptual Paper

Introduction

In this unprecedented globalised era, where humans, objects, data are more interconnected than ever, the 4th Industrial revolution is set to bring it to another level. Companies are leveraging on disruptive technologies to achieve competitive advantages. (Angappa et al., 2017).

The first two industrial revolutions had bought on the modern life necessities such as steam water power mill and electricity. The 3rd industrial revolution formed the roots for modern day landscape such as emails for daily work communication, invention of printed circuit boards that are present in almost all electronic appliances, all of which are incorporated in today's revenue generating activities. (Nicholas, 2017)

In pursuit of progresses, the 4th industrial revolution has sprung up in recent years. It seeks to 'disrupt' the existing logistics and supply chain management landscape through disruptive technologies and corporations are incrementally adopting disruptive technologies such as Amazon's kiwi robots in their warehouses (Amazon robotics., n.d.) and Foxconn's Foxbots (Kristin 2017)

Moving forward, many corporations are under pressure to follow suit or risk been made obsolete by market forces. Work processes are expected to transform with the adoption of disruptive technologies and workers will have to learn, unlearn and relearn knowledge, skills in order to bridge gaps in manpower's competencies and abilities. Therefore, lifelong learning and upskilling through work-based training will be pertinent so as to meet the demands in the work transformation processes.

This paper examines three key areas in relation to the impact of disruptive technologies. They are: (1) what are the potential benefits in adopting disruptive technologies in logistics and supply chain management (LSCM)? (2) how can organisations manage challenges in process transformations based on a lean perspective and (3) what are the relevant skillsets that the future of work will entails in LSCM?

In similar vein, the objective of the lean methodology has traditionally been in cutting waste and improving the efficiency of operations through the eliminations of bottlenecks in the processes. We posit that LSS complements the rationale for the adoption of disruptive technologies in operations and process in optimising the output of logistics and supply chain processes. Both seeks to improve operational visibility and process performance

The rest of the paper is structured as follows. Section 2 explains the method of this study and provides background for the conceptual paper. Section 3 first presents a general overview of the relevant literature that are systematics reviewed and analysed to address our subsequent address to the three research questions. Section 4 presents the findings in response to the three research questions. Section 5 summarises the chief findings of this study, and section 6 discusses potential implications of the study to practice and research in the adoption of disruptive technologies in LSCM.

Research Method

Although Industry 4.0 and the relevant disruptive technologies have received a lot of attention recently in practitioner oriented articles, research in this area remains scarce. An exploratory research approach is employed as we aim to provide a holistic overview of the implications of Industry 4.0 in LSCM by addressing the prior research questions. The exploratory study involves an initial phase of narrowing down the relevant literature in Industry 4.0 and the context of LSCM. This was accomplished through an extensive desk research on extant literature and accompanied with multiple unstructured discussions within the research team of the authors and practitioners whose organisations and operations are involved in implementing change and transformations in their work processes.

Literature – A Systematic Review

Logistics operations has evolved from military context in the 18th Century of troops management (Michael et al., 2005) to today volume of 85 million packages and documents delivered around the world at any single day. These massive delivery volumes reflect the huge number of jobs generated from the sector. Traditionally, the logistics and supply chain management function had been viewed as a cost centre, associated with laborious and heavily dependent on human resources.

Streamlining LSCM operations have been an incessant issue as output variability is high in work processes that are infused with tasks that are performed by operators that are proficient at work to different degrees. Variance in the knowledge, skills and abilities of workers further add onto the pyramid of spatial factors, making it a challenge to achieve an optimal output in logistics operations.

Research has shown that logistics and supply chain companies are adapting disruptive technologies to collaborate with manufacturers for real time data exchange for supply chain visibility. Manufacturers are introducing robots to assist workers on repetitive strenuous tasks ("BMW Group Harneness"., 2017) robots are used in warehouses to enable automated picking and packing processes (Sam, 2017) and cyber physical systems are used to allow synchronised decision marking through a real time view, discussion and analysis of critical information on a dash board (Hofmann & Rusch, 2017). These disruptive technologies will shape a new way of working and an updated need on skill profile and manpower competencies. Insights on the benefits promised by the adoption of disruptive technologies is presented in the findings section.

Findings

The findings section is structured in three sections in accordance to the three guiding research questions that this study has raised.

Research question (1): What are the potential benefits in adopting disruptive technologies in logistics and supply chain management (LSCM)?

These technologies are likely to bring about changes to existing job processes, information visibility and accuracy and manpower allocations. What is more pertinent is that disruptive technologies seek to eradicate the bottleneck issues the industry have been facing. These technologies and its potential benefits are summarised in Table 1.

Potential benefits	Technologies
Maximise operational output by 24/7 utilisation	Self-driving vehicles (Logistics Trend Rader, 2016)
Real time data visibility (Hofmann & Rusch, 2017)	Cyber physical systems
Predictive modelling and advanced decision making	Big data and data analytics
Increases the company's agility to market fluctuations thereby achieving a lean deployment.	Autonomous robots (Logistics Trend Rader, 2016)
Shortening of logistical turnaround time effectively	Internet of things (Witkowski, K. 2016)
An alternative to last mile delivery transport with a potential of shorter turnaround time	Drones (Logistics Trend Rader, 2016)

Table 1. Summary of Technologies and Potential Benefits

Research question (2): How can organisations manage challenges in process transformations based on a lean perspective?

Lean management in an era of disruptive technologies

Invented by Henry Ford (Lean History, 2017) and successfully implemented by Toyota (Lean Origin, 2017), lean aims to create value with minimal resources, the lean principle prescribes an operational system that places emphasis on results and effectiveness rather than process and not a system that proposes standardized management logic (Fullerton and McWatters, 2001). The central idea in the "lean principle" is the removal of unnecessary waste during the production process. If resources are consumed without creating value, they become waste. Ohno (1998) defined seven types of waste that create no value: Over-production, defects, inventory, transportation, waiting, motion and over-processing. Liker (2004) proposed an eighth type of waste: inappropriate design. If these categories of wastes can be

removed and the manufacturing process continually improved, a perfect lean production enterprise should be an achievable goal.

This underlying motivation that endeavour to improve the efficiency of effectiveness of operations and work process resonates with the adoption of disruptive technologies. Organisations can attempt to adopt lean methodologies to make systematic process transformations. Table 2 provides an overview of the eight forms of waste that are commonly abbreviated as "TIMWOOD" (lean, 2107)and examples of waste under each category in the lean literature.

Abbreviations	Waste Category	Example of waste
T	Transportation	Excessive transportation of inter-plant cargoes due to lack of appropriate vehicles
I	Inventory	Holding more inventory than what is required to service their stakeholders
M	Motion	Extra time and steps spent searching for correct cargo location, tools and equipment
W	Waiting	Time spent waiting for upper stream stakeholders such as order generation
O	Over processing	Prepare more than what their stakeholders require with a mindset of being able to complete the work in advance
O	Over production	
D	Defects	Mishandling of equipment, tools and cargoes

Table 2. Categorization of the eight types of wastes under lean management

High quality by adopting lean in disruptive technologies

Certain skills such as physical labour and manual dexterity are expected to be displaced by disruptive technologies. This signifies a need for transformations in logistics operations and supply chain processes. Lean is an established management philosophy, which has been widely applied in process streamlining and operations improvements. By adopting lean tools, organisations can expect to produce high quality work by improving TIMWOOD. This has to be done from ground up perspective where the stakeholders' voices are heard:

Objectives	**Tools**
To understand internal and external stakeholders' requirements bought on by disruptive technologies	Voice of customers
1) Holistic view of existing department and inter-department processes 2) To analysis for signs of ineffectiveness and/or inefficiencies along the work processes	Value stream map/swim lane diagram
Takes into account all major and its sub problem causes systematically. This allows for an informed and critical analysis of the problems	Ishikawa diagram
A mistake proofing tool that attempts to acts as a 'gate keeper' by informing the executor when the variables of the tasks being performed are not met. Related technologies can be programmed to assist the worker in this aspect.	Poka Yoke
Provides real time data for synchronised analysis and decision making on a strategic, tactical and functional level.	Dashboard

Table 3. Categorization of the eight types of wastes under lean management

Lean tools can be introduced at different stages of process streamlining to ensure a careful and sequential transformation. (Martin J.W., 2017) If implemented correctly are expected to bring about the improvements of various (non-exhaustive) performance metrics. As depicted in table 4, various sets of lean tools can be applied to address issues in relations to the performance metrics that are tracked by many organisations such as the customer satisfaction level and order accuracy. The list in table 4 is not exhaustive.

Tools	Performance metrics
Voice of customer	Customer satisfaction level
Swim lane diagram	Work process throughput
Ishikawa diagram	Order accuracy level
Poka Yoke	Improved order accuracy

Table 4. Categorization of the eight types of wastes under lean management

Besides addressing the process changes in an organization, people in the organization needs to be trained and equipped with the necessary skill sets and knowledge in order to work in synergy with technologies. In the following section, we address the third research question and shed light on the core skill sets that would be relevant and beneficial with the transformed operations so that people can be competent to work seamlessly with advanced technologies in the future of work.

Research question (3): What are the relevant skillsets that the future of work will entails in LSCM?

All in all, as the industry is expecting major changes to its work processes, it does not seek to eliminate humans from its processes. Rather, it attempts to bridge the gap between existing performance and desired performance.

We are also at an intersection era where non-digital natives and digital natives are going through different form of transformation to eventually live and work with the 4th industry revolution. However, there have been fears of disruptive technologies replacing their existing jobs. (Joerres et al., 2016)
Demand for existing skill sets may be significantly reduced, either across the industries or aggregately whereby workers' skill is still required but in new industries bought on by 4th industry revolution effects. New domain knowledge and skills may emerge too. (Joerres et al., 2016)

The logistics and supply chain industry is expecting significant growth due to increasing globalisation and supply chains being more connected/intertwined than ever. To fill up the knowledge and skills gap and manage the growth, it is pertinent the government, industry leaders, educational institutions collaborate to manage the change effectively across all levels (strategic, tactical and operational). Domain and quantitative knowledge are expected to be the key drivers in training an effective supply chain data scientist (Waller M.A., Fawcett S.E., 2016) who will exploit the technologies to maximise its benefits for businesses.

Research has shown, practical skills have equal importance with formal qualifications. Certain skills that involves physical labour and manual dexterity might be close obsolescence whilst technological familiarization and cognition skills that facilitates the connections of machines and human will be of core importance across various technologies (Joerres et al., 2016). Table 2 provides an overview of the relevant skills family and technologies that will be of importance in this age of disruption. These skills are expected to be high in demand or at least stay at current demand by 2020 in the logistics and supply chain industry (Joerres et al., 2016).

Along with retraining, workers will be expected to have increased ownership in their work pertaining to utilisation of the technologies. Managing the change barriers and risk effectively (Joerres et al., 2016) envisages a relationship where digitalisation and automation complement organisations to bring about competitive advantages and better quality of work and life. To manoeuvre the intricacies of process transformations, human resource management and manpower competency in relations to the skill sets are highlighted in Table 5.

Technologies	Skills family	Skills
Self-driving vehicles	Content skills Social skills	ICT literacy and active learning Coordination
Cyber physical systems	Social skills	Emotional intelligence Coaching Negotiation Coordination Communication
Autonomous robots	Content skills Social skills	ICT literacy and active learning Coordination
Internet of things	Cognitive abilities Social skills	Logical processing Coordination
Drones	Resource management skills Social skills	Managing of Financial, Materials, People and Time resources. Coordination
Big data and Data analytics	Complex problem solving Social skills Process skills	Complex problem solving Emotional intelligence Coaching Negotiation Coordination Communication Active listening and critical thinking

Table 5. Summary of Technologies and Potential Benefits

Industry 4.0 - Manpower training and Skillsets

The research methodology had proposed a change in workers' skills with the introduction of disruptive technologies, as such, human resource management is critical is to ensure smooth process transformation. It is recommended to incorporate human elements in readjusting manpower deployment.

Along with adapting disruptive technologies, the organisations have to consider human resource management in their business transformation strategy to achieve high receptivity by internal stakeholders. It is recommended to take an incremental approach with constant communication and education as changes are often met with resistance.

Managers at different level should demonstrate skills listed in table 2 which are instrumental in change management. It is recommended to introduce incremental changes through pilot tests and identify receptive workers to be involved in the tests and leverage on their sphere of influence to educate and transform the mindset of less-receptive workers.

While human redundancies are expected in Industry 4.0 with the introduction of various technologies throughout the decades, communicating the idea of human-technologies collaboration and predecessor cases is expected to assist the workers in accepting these changes.

Conclusions and Implications

The paper explored and discussed the potential benefits and changes brought on by disruptive technologies and how it can be managed by lean six sigma and human resource management.

While there has been extensive research on disruptive technologies, little has been said on managing these technologies on an operational level and the changes that comes along with it. To ensure the

success of disruptive technologies implementation, it is critical to manage change effectively. Effective management would mean a transformed organisational strategy and better quality of work.

The paper attempts to provide a better understanding on the implications of Industry 4.0 on LSCM by first setting out the key challenges that logistics and supply chain companies face in digital transformation and the potential benefits from the successful adoption of exponential technologies. To aid companies in successfully manoeuvre the transformation brought about Industry 4.0, the paper focused on how companies can transform work processes in the digitalised age by using a systematic approach that is guided by the lean philosophy to bring about simplification in processes and operational complexity. In addition, this paper provides insights on the core skill sets that workers have be equipped with in order for them to work seamlessly with disruptive technologies. Overall, this paper serves as a source of reference for organisations that seek to adopt these technologies on its selection and management- Planning, Organising, Leading and Controlling (Robbins and Coulter, 2014). For consultancies and learning institutions, this work may serve as a new school of thought in pushing for mass adaptation of disruptive technologies and operational transformations in logistics and supply chain management.

References

- Angappa et al. (2017), "Information technology for competitive advantage within logistics and supply chain" Transportation Research Part E, 99, 14-33
- "A brief history of lean" (n.d.). available at https://www.lean.org/WhatsLean/ (accessed 26 August 2017)
- "Amazon robotics". (n.d.). available at https://www.amazonrobotics.com/#/ (accessed 16 July 2017)
- "BMW Group Harnesses Potential of Innovative Automation and Flexible Assistance Systems in Production". (n.d). available at https://www.press.bmwgroup.com/global/article/detail/T0268199EN/bmw-group-harnesses-potential-of-innovative-automation-and-flexible-assistance-systems-in-production/ (accessed 23 July 2017)
- Davis, N. (2016) "What is the fourth industrial revolution?", available at https://www.weforum.org/agenda/2016/01/what-is-the-fourth-industrial-revolution (accessed 16 July 2017)
- Fullerton, R.R. and McWatters, C.S., 2001. The production performance benefits from JIT
- implementation. *Journal of operations management*, *19*(1), pp.81-96.
- Hofmann, E., & Rüsch, M., 2017. Industry 4.0 and the current status as well as future prospects on
- logistics. *Computers in Industry, 89*, 23-34.
- Houser, K. (2017), " Apple Manufacturer Foxconn to Fully Replace Humans with Robots ", available at: https://futurism.com/apple-manufacturer-foxconn-to-fully-replace-humans-with-robots/ (accessed 16 July 2017)
- Industry 4.0 (2017), Deloitte University Press, available at https://dupress.deloitte.com/dup-us-en/focus/industry-4-0.html?icid=left_industry-4-0/ (accessed 4 September 2017)
- Joerres et al., 2016, "WEF_Future_of_jobs", available at http://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf (accessed 27 July 2017)
- Liker, J.K., 2004. The 14 principles of the Toyota way: an executive summary of the culture behind TPS. *The Toyota Way*, *14*, pp.35-41.
- "Logistics Trend Radar". (n.d). available at http://www.dhl.com/content/dam/downloads/g0/about_us/logistics_insights/dhl_logistics_trend_radar_2016.pdf/ (accessed 23 July 2017)
- Meredith, J., 1993. Theory Building through Conceptual Methods. *International Journal of Operation*
- *& Production Management, 13*(5), 3-11.
- Martin, J.W., (2017) Lean Six Sigma, Mc Graw Hill Education, United States of America
- Ohno, T., 1988. The Toyota production system: beyond largescale production. Portland: Productivity Press.

- Robbins, S.P. & Coulter, M., (2014). Management, 12th edition. London: Pearson Education Limited
- Taylor, M., Yue, WL., and Tseng YY (2005), The role of transportation in logistics chain, proceedings of the Eastern Asia Society for Transportation studies vol 5 pp. 1657 – 1672
- "The origin of the Toyota Production System" (n.d.), available at global.com/company/vision_philosophy/toyota_production_system/origin_of_the_toyota_production_system.html (accessed 26 August 2017)
- "What is lean" (n.d.). available at http://asq.org/learn-about-quality/lean/overview/overview.html (accessed 26 August 2017)
- Witkowski, K. (2016) Internet of Things, Big Data, Industry 4.0- Innovative Solutions in Logistics and Supply Chain Management, 182, 663-769.
- Wang G., Gunasekaran A., Ngai E.W.T., Papadopoulos T., 2016. Big data analytics in logistics and supply chain management: Certain investigations for research and applications
- Waller M.A., Fawcett S., 2016. Data Science, Predictive analytics, and Big Data: A revolution that will transform Supply Chain Design and Management.