Examining the Role of Procurement 4.0 towards Remanufacturing Operations and Circular Economy

Dr. Surajit Bag

Post Graduate School of Engineering Management,

University of Johannesburg, South Africa

Email: surajit.bag@gmail.com

Dr. Pavitra Dhamija

Department of Industrial Psychology and People Management,

College of Business and Economics,

University of Johannesburg, South Africa

Email: pavitradhamija@gmail.com

Dr. Shivam Gupta

Department of Information Systems, Supply Chain & Decision Making,

NEOMA Business School,

59 Rue Pierre Taittinger, 51100 Reims, France

Email: shivam.gupta@neoma-bs.fr

Prof. Uthayasankar Sivarajah*

School of Management,

University of Bradford,

Richmond Road, Bradford BD7 1DP, United Kingdom

Email: u.sivarajah@bradford.ac.uk

(*: Corresponding Author)

Abstract

Procurement digitalisation can provide significant opportunities for excellence in remanufacturing operations. The close attention of firms is required during the configuration of procurement 4.0 resources for applying front end and base technologies in order to develop the correct set of these resources. Based on Resource Based View theory, this research examines the role of resources influencing procurement 4.0 for driving productivity in remanufacturing operations and circular economy performance. The survey data for this research was gathered from working professionals in South Africa and results reveal that technological resources are necessary in procurement 4.0, which can in turn improve the productivity in remanufacturing operations. An upsurge in performance in remanufacturing operations can enhance the circular economy outcome. To the best of authors' knowledge, this study is the first to provide insight for researchers, practitioners and academics with an empirical test of digital procurement on remanufacturing operations and of circular economy performance in an emerging economy like South Africa.

Keywords: Procurement 4.0; Circular Economy; Digital Procurement; Emerging Economy; Resource Based View Theory

1. Introduction

The fourth industrial revolution (Industry 4.0) has revolutionised almost every aspect of business process including procurement activities which has in turn evidenced the emergence of the concept of procurement 4.0 (P4.0) (Bag et al., 2020a; Croom 2000). Procurement denotes acquisition of various goods or services based on contract terms and conditions (Bag, 2020a). The key elements of procurement include activities such as deciding of approved contractor, documenting the purchase of raw material, and building and maintaining cordial relationship with the suppliers (Moktadir et al. 2020; Knudsen 2003). In this context, P4.0 is the digitalisation of procurement activities in order to drive efficiency and automate the process (Bienhaus and Haddud, 2018). This research focuses on the role of resources for P4.0 from the perspective of remanufacturing operations and circular economy (CE). In order to understand the said aspect, it is worthwhile to understand the importance of three types of major resources (i.e. talent, management and technological) that evidence significant contribution towards P4.0 operations.

Digitalisation, shortage of labour, takeovers and acquisitions and cut-throat competition globally is signalling talent as one of the top priorities contemporarily (Nicoletti 2018). Furthermore, the culture of sustainable growth and development is increasing pressure on organizations to introduce innovative procurement ideas for better supply chain operations (Barney, 2012); which is possible only with good talent resources (Waller and Fawcett, 2013). The workforce dealing with procurement now-a-days is expected to be logical and smart (Guide Jr, 2000). The ability to handle numbers, followed by critical analysis and interpretation is one of the keys to attain successful P4.0 (Guide Jr et al., 2000). Management of operational activities is one the toughest tasks to be accomplished on day to day basis (Guide Jr et al., 2003). With respect to P4.0, the management of activities or processes occupies a centre stage among all associated procurement tasks (Jinhui and Closs, 2009). Management of organizational procurement activities involves a great deal of strategic coordination with key stakeholders (Kunz and Gold, 2017). Some of the activities that require management resources in P4.0 include formation of service level agreements with suppliers, maintenance of procurement intranet website, frequent project reviews, stakeholder's satisfaction surveys and identification and implementation of improvement opportunities (Bienhaus and Haddud, 2018). Technological resources contribute greatly towards P4.0 (Choe et al., 2015). It enables quick and streamlined procurement operations with less cost and time (D'Addona et al., 2018). The association of technology in procurement processes denotes usage of smart and intelligent tools to achieve strategically designed aims and objectives (Datta, 2017). Enterprise resource planning is one such system that facilitates integrated and automated procure-to-pay processes (Ivanov et al., 2018). Procurement comprise of many sets of activities and tasks that can be done electronically (Kirci and Seifert, 2015). Digital orders and invoices, automatic optimisation of inventories, barcoding used for material handling in warehouses are few of them to mention (Ivanov et al., 2018). Though research team could acknowledge traces of P4.0, yet there is a need to explore more about three resources with an intention to deal with the first research question: *RQ1. What are the major resources that contribute towards Procurement 4.0?*

The other endeavour of this work is to scrutinize the contribution of P4.0 towards remanufacturing and Circular Economy (CE) performance. Remanufacturing process (refer to Figure 1 for process overview) deals with restoration of an old or second-hand product to functional state (Rakovska and Stratieva 2018). The like-new product is a combination of substantial portion of original material used during its first make and small portion of new material (Kamble et al., 2018). This process not only saves resources but also generates a product at minimum additional expenditure (Katiyar et al., 2018). It is pertinent to mention that due to unsustainable processes of production, consumption and utilisation of renewable/non-renewable resources is depreciating the environment globally (Liebman and Mahoney, 2017). Lately, the remanufacturing of old products has become an essential aspect of production across industries worldwide (Bienhaus and Haddud, 2018). Procuring and assembling a like-new product is even more difficult in comparison of producing a new first make product (Macchion et al., 2018). Alike remanufacturing, the application of CE concept has gradually gained momentum (Esposito et al., 2018). Giving due importance to the novelty of the study, this research proposes to examine the association between P4.0 and remanufacturing productivity and CE performance and realises that the consulted literature could not assure a great contribution towards this area, which justifies the gap in selected topic and the reason to conduct this valuable research (Moktadir et al., 2020). The author's aim to link P4.0, remanufacturing productivity and CE performance, and look to deal with the second research question: *RQ2. How does Procurement 4.0 influence remanufacturing productivity and Circular Economy performance?*

The next section presents the literature review and underpinning theory that is used to explain the relationships, to be followed by section 3 on hypotheses development. Section 4 presents the research methods used to perform the empirical survey and section 5 provides data analysis and results. Section 6 and 7 discusses the objectives and showcases the theoretical and managerial contributions of this study.

2. Literature Review

2.1 The Role of Resources for Procurement

Procurement is an essential function in supply chain management (SCM) that greatly influences the organizational performance (Chen et al. 2004; Bag et al. 2020a, b). Procurement process is successfully implemented only with the availability of certain resources (Oh et al., 2014; Moktadir et al., 2020). Resources includes raw materials, direct goods and services, indirect goods and services and financial expenditures; whereas the capabilities covers cost reducing efficiencies while maintaining good relationship with internal and external suppliers and integration capabilities of procurement process in fitment to other processes in entire SCM (Tai, 2014; Ghisellini and Ulgiati, 2020).

It is worthwhile mentioning that procurement postulates an indispensable part of SCM and requires an in-depth exploration from the perspective of I4.0 (Brettel et al., 2014; Kim, 2017; Lamba and Singh, 2017; Niranjan et al., 2018). Procurement is a systematic procedure for sourcing materials and services on the specified terms and conditions of an agreement between involved vendors (Walker and Hampson 2008; Kunz and Gold 2017; Bienhaus and Haddud 2018). This process ensures the availability of desired goods and services to the buyer by the supplier, in order to deliver the finest quality and quantity in the best possible time and for the best possible cost (Choe et al. 2015; D'Addona et al. 2018). Procurement-oriented decisions are extremely important to ensure a smooth process of supply chain management (Datta, 2017; Ivanov et al., 2018). It involves a series of actions that are repetitive in nature before the final product is generated (Dolgui and Ould-Louly, 2002). Dolgui and Proth (2013) highlight the importance of flexibility between buyer and vendor and supply chain in the form of multi-stage networks implemented throughout the supply chain management. The anticipated growth of digitalisation and I4.0 influences the existing set-up of supply chain processes in terms of new models and principles (Kirci and Seifert, 2015; Ivanov et al., 2018; Rakovska and Stratieva, 2018).

Certain supply management challenges in procuring remanufactured products include the doubtful quality of old/used products (Merkert et al., 2018), inadequate examination of old/used products (Dubey et al., 2017a), variability in the expected output of old/used products (Dubey et al., 2019), higher additional cost of remanufacturing for old/used products (Kirchherr et al., 2017), complex inter-dependent multistage process of remanufacturing old/used products (Vanegas et al., 2018), procurement of suitable old/used products among wide variety of available products (Linder and Williander 2017) and complementing the reassembled product in accordance with customer requirements (Brown and Bajada, 2018).

These challenges can be overcome with the introduction of P4.0 in the organization (Bag et al., 2020a).

2.2 Procurement 4.0 and Circular Economy

Extant literature has suggested that information technology alignment within procurement function can satisfy the supply chain needs and further generate value over time that can provide competitive advantage to the firm compared to the competitors (Mikalef et al., 2013; 2014). The adoption of I4.0 has genuinely changed the path of sustainable procurement processes for the organisations (Kamble et al., 2018; Katiyar et al., 2018; Liebman and Mahoney, 2017). The present paper is an attempt to realise the importance of digital procurement or P4.0 by focussing on its major constituents i.e. talent resources, technological resources, and management resources.

P4.0 is the digitalisation of procurement activities to automate the process (Schiele 2007; Bienhaus and Haddud, 2018). Strategically, P4.0 focuses on six major areas that form its resources and a comprehensive P4.0 framework has been proposed by Schrau and Berttram, (2016). The procurement 4.0 framework (refer to Figure 2) highlights the trends and drivers and digital procurement revolution, evolution and base for effective digital procurement. The shared framework has touched six major areas that provide substantial understanding of the required resources of P4.0.

P4.0 offers several benefits to firms, such as daily purchasing jobs, administrative work, increased efficiency, quality decision-making, improved effectiveness, and enhanced business profitability (Bienhaus and Haddud, 2018). It makes strong connections between the procurement and supply chain team and all other tiers in supply base, making all relevant data (cost, stock availability, delivery lead times, financial, and operational risks) available to the focal firm, and thereby providing complete visibility (Schiele, 2007). The transaction time is reduced by 30-50 percent and value leakage by 50 percent respectively (Macchion et al., 2018; Merkert et al., 2018). Thanks to adverse pieces of environmental evidence from across the world, there is a growing understanding of sustainable manufacturing practices (Dubey et al., 2015a, b).

Sustainability aspects from technological application perspective require closer attention (Josserand et al., 2018). Sustainable manufacturing involves procedures, which can result in the conservation of natural resources, minimising the overconsumption of non-renewable resources while fulfilling the present needs, and not compromising future requirements (Fay et al., 2015; Giret et al., 2015; Perey et al., 2018). Sustainable processes not only prove safe for suppliers and consumers, but also significantly contribute towards the growth and development of the economy on a larger scale (Schiele, 2007; Dubey et al., 2017a; Dubey et al., 2019).

The supply chain processes result in wastage of resources that is left as residual at the end (Agrawal et al., 2015; Fahimnia et al., 2015). The aim of every organisation is to gain maximum profit with minimised expense and wastage by adopting the 3-R Principle (Reduce, Reuse and Recycle), which is in turn related to the concept of CE (Lieder and Rashid, 2016; Geissdoerfer et al., 2017). The introduction of CE significantly heightens the need to study how sustainable P4.0 influences the CE performance (Kirchherr et al., 2017; Vanegas et al., 2018).

CE as an economic system focuses on waste minimization and optimal use/re-use of resources (Hopkinson et al., 2018). Though remanufacturing and CE concepts appear similar in general, but they are different from P4.0 perspective (Kunz et al., 2018) (refer to Figure 3). The major difference is that CE forms a part of macro-economic concept. CE extends certain benefits that include avoidance of resource scarcity for businesses, handling unpredictable prices, generation of opportunities and energy conservation (Zheng et al., 2018). In the Figure 3, remanufacturing is placed at the outer of both reuse and repair, which facilitates remanufacturing to provide resource effective manufacturing units and become a good fit in a CE (Ghisellini and Ulgiati 2020).

The prospect of CE is opening new doors to experiencing an improved and sustainable economy for different nations globally (Masurel, 2007). The technological contribution towards supply chain processes at large and procurement in particular highlights the association between Big Data Analytics (BDA) and SCM (Dubey et al., 2015a; Gandomi and Haider, 2015; Giret et al., 2015; Bag et al., 2020a). The concept of CE demonstrates that stakeholders and policy makers must ensure the appropriate circulation and re-circulation of resources towards desired sectors. The reuse or recycling of resources is key to CE (Katz-Gerro and Lopez Sintas, 2018). Hazen et al. (2017) assert that there exists a strong relationship between SCM and operations management in a CE. Gradually, the world is focusing on CE with an aim of improving environmental quality, economic prosperity, and societal development (Geng et al., 2012, 2013; Kirchherr et al., 2017; Esposito et al., 2018; Hopkinson et al., 2018; Kunz et al., 2018). Firms like Caterpillar Inc., Autocraft Drivetrain Inc., Robert Bosch GmbH and Detroit Diesel Corporation have adopted remanufacturing principles to meet sustainable development goals. However, there are several challenges in remanufacturing practices with respect to the conservation of non-reusable sources of resources (Zheng et al., 2018a,b,c). The major challenges associated include uncertainties in sustainable quality and quantity of product returns (Bag et al., 2018a, 2018b).

Merkert et al. (2018) conveys the two categories of methods used in digital procurement: (a) tools that help to identify and create value support in order to provide visibility and aid in advanced collaborative sourcing and, (b) tools that will prevent value leakage including enterprise resource planning (ERP) and operational systems to deal with procure-to-pay and to manage supply performances.

The ability to apply front end and base technologies can be developed by identifying suitable resource sets that will prove useful in integrating risks and reconfiguring processes (Frank et al., 2019). The performance of supply chain process is highly reliant upon the sustainability aspect of the supply chain itself (Dubey et al., 2017b; Manogaran et al., 2018; Gupta et al., 2019). The undefined environmental risks must be accounted for design of SCM network (Schiele, 2007). Dubey et al. (2017a) explain the importance of sustainability socially and environmentally in SCM. In addition, BDA significantly (positively) influences the agility in supply chains to receive the competitive advantage (Mikalef et al., 2018). Organisational flexibility throughout this course of action further strengthens the process (Dubey et al. 2018).

Isil and Hernke (2017) convey a healthy association of triple bottom line and corporate sustainability with special reference to supply chain management in manufacturing organisations. Fraccascia et al. (2019) observes a problematic link among sustainability and CE. Prieto-Sandoval et al. (2018) and Van Loon and Van Wassenhove (2018) consider CE to be a one-stop solution for reducing environmental degradation and increasing sustainable manufacturing. Brown and Bajada (2018) argue that, although existing principles of CE are essential to attain sustainability, the practical implementation of CE remains a sticking point. P4.0 resources comprising of talent, technological, and management resources can be integrated and reconfigured to apply P4.0 front and base technologies, which will improve remanufacturing productivity and remanufacturing business profitability during uncertain times in order to achieve CE goals for sustainability (Glas and Kleemann, 2016; Gaustad et al., 2018; Low and Ng 2018).

2.3 Resource Based View (RBV) theory

The RBV theory of the firm is a good way in identifying the internal root that can decide competitive gains (Wernerfelt, 1995; Barney et al., 2001). However, managers following RBV theory may not focus too widely on every resource and they may not even analyse properly the connections existing among various resources and their associated connections with environment. The case of American airlines clearly indicates that managers need to gauge resources properly with a wider context. Successful businesses preserve set of resources that are precious, uncommon, matchless and hard to replace. Situations may change in this highly volatile business environment and firms must avoid focusing too narrowly on the resources to avoid risks. In a firm there are multiple functions such as sales, operations, finance, human resources and therefore, resources must be assessed across all these functions. Few resources may be required in particular situations while they may not be required in other situations. However, managers must have an overview of all the available resources and more importantly they must understand how each of these resources interacts with each other and conditions under which each of them maintains or drop importance. It is also indicated that higher level of competition augments the values of resources (Teng and Cummings, 2002). Resources are possessed or controlled by the firm whereas capabilities are the abilities of a firm to position resources using its business processes (Ravichandran et al., 2005). In the past several scientific works have adopted RBV theory in identifying resources (tangible, intangible and human skills) for BDA capabilities (Gupta and George 2016). Information technology resources comprises of tangible resources (IT infrastructure); human resources (technical and managerial IT skills) and intangible resources (knowledge, customer orientation and synergy) that can enhance innovation in the organization (Bharadwaj, 2000). Wade and Hulland (2004) using RBV theory also suggested six conventional resource features that are important in information systems research. The next section presents the theoretical framework with testable hypotheses.

3. Theoretical Framework and Hypotheses Development

We leverage RBV theory to demonstrate how talent, technology, and management resources influence P4.0 and productivity in remanufacturing operations in uncertain times, and to understand how it influences the CE performance.

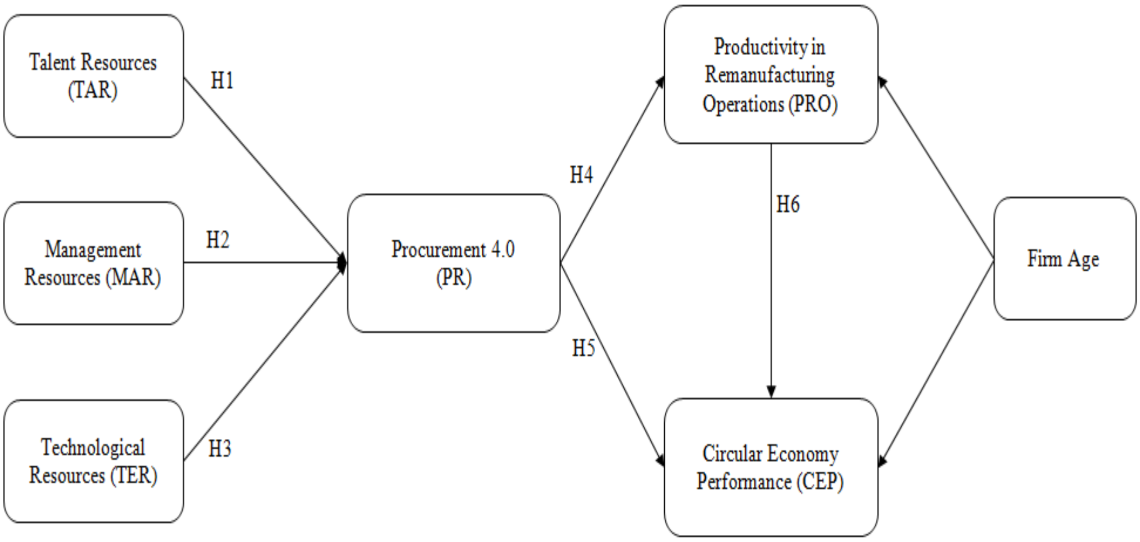

Figure 4: Theoretical Framework

3.1 Talent Resources and Procurement 4.0

Talent resources have a strong relationship with P4.0 (Bray, 2019). It includes the ability of analytics personnel to do advance programming; to manage digital project lifecycles, data, networks and maintenance; to create a DSS driven by analytics, the interpretation of data, a good understanding of technological trends and key success factors of organisation, knowledge about all business functions; and to maintain long-term customer relationships (Akter et al., 2016). An organisation must focus primarily on developing talent resources towards P4.0 projects (Waller and Fawcett, 2013; Nicoletti, 2018). The human resource managers design training and continuous education programmes to develop skills among existing employees to then fit into the P4.0 system. Accurate job descriptions and interviews from a committee made up of experts generally aid in the selection of the right candidates with the ability to understand the environmental uncertainty and to manage data and analytics for business growth. The effective management of such a resource pool and retaining talent are difficult tasks and human resource managers have been coming up with innovative ways of keeping such talent assets in the organisation in the long term (Nicoletti, 2018). Hence, talent resources are one of the engines that will further aid in building P4.0 capability (Akter et al., 2016). Therefore, we hypothesise:

H1: Talent resources have a positive impact on P4.0

3.2 Management Resources and Procurement 4.0

Management resources are basically a bundle of resources that play a critical role in P4.0 projects' success, together with talent resources and technological resources (Bag et al., 2020a). The managing of P4.0 projects require focus on both macro and micro-level activities that could potentially influence the success of such projects. The building of management resource sets involves enforcing high-level strategic plans for the introduction and exploitation of P4.0 systems (Bag et al., 2020a). In addition, top management will always look for innovative opportunities to achieve desired outcomes from P4.0 projects. The involvement of top management and review helps in carrying out the P4.0 planning process in a systematic way (Bienhaus and Haddud, 2018). However, frequent adjustment of P4.0 plans is required in coordination with changing business demand conditions. The top management assess P4.0 investment decisions from productivity perspective before making any investment decisions. The organisation of cross-functional meetings generally proves fruitful for key P4.0 business process management decisions (Luthra and Mangla, 2018). Setting key performance goals makes the objectives clear for employees and increases job effectiveness. Top management focus on P4.0 projects gives employees the confidence that P4.0 project proposals will be properly appraised. Management support and regular reviews are effective in achieving desired outcomes and it is important that the importance of management resources is recognised in P4.0 projects (Akter et al., 2016). Therefore, we hypothesise:

H2: Management resources have a positive impact on P4.0.

3.3 Technological Resources and Procurement 4.0

Information systems provide visibility to enhance the level of responsiveness (Lau and Lee, 2000; Williams et al., 2013). In remanufacturing operations, it is important that firms link business targets and operational targets to remanufacturing unit activities (Wang and Wang 2019). The focus is on the integration of multiple firms, operations and automation at shop-floor level in order to attain an improved performance in comparison with current setup and enhance performance. An end-to-end connectivity using I4.0 technologies to connect suppliers to the shop floor and the final user is the key to success in volatile business environment (Telukdarie et al., 2018). It is important for an organisation to apply front-end technologies like smart manufacturing, smart supply chain, smart product and smart working and base technologies like artificial intelligence, internet of things, cloud computing and big data predictive analytics (Sivarajah et al, 2019; 2017) at a global level by connecting all the plants. This takes place subsequently at the divisional level connecting all divisions and then, thirdly, at the functional level connecting all business functions that leads to development of P4.0 (Khuan and Swee, 2018; Frank et al., 2019). Therefore, we hypothesise:

H3: Technological resources have a positive impact on P4.0.

3.4 Procurement 4.0 and Productivity in Remanufacturing Operations

I4.0 has given rise to the P4.0 system. It integrates everything to enable a seamless flow of information (Graham et al., 2015; Bienhaus and Haddud, 2018). The main emphasis in the era of I4.0 is digitalisation where the key focus is on artificial intelligence and machine learning; vertical and horizontal communication, and human-machine interaction (Telukdarie et al. 2018). P4.0 enabled technologies can be useful to provide timely information and to optimise the procurement process (Zhang 2018a, 2018b, 2018c; Bienhaus and Haddud, 2018). The P4.0 plan must be aligned with the company's goals and strategies related to remanufacturing operations. P4.0 will enhance visibility, thereby aiding in arranging timely deliveries and avoiding further production delays (Bag et al., 2020a). The information made available by data analytics related to market intelligence and global supply pricing trends will result in procurement and cost control in remanufacturing (Wang et al., 2016; Jiang et al., 2019). Buyers can optimise energy, save scarce natural resources, and reduce procurement cycle time. This will help in developing the ability to run agile and customer-driven procurement (Akter et al. 2016). Therefore, we hypothesise:

H4: P4.0 has a positive impact on productivity in remanufacturing operations.

3.5 Procurement 4.0 and Circular Economy Performance

P4.0 includes the digital procurement abilities of a firm to effectively execute long and short-term procurement strategies. P4.0 comprises of holistic vendor management systems and automated systems. These systems improve communication not only between buyer and suppliers, but also between transport vehicle to vehicle and vehicle to infrastructure (Khuan and Swee, 2018). The inter-connection of internet of things aids in the execution of procurement operations remotely with smart phones and laptops. The smart objects fitted to transport vehicles and storage equipment and destinations can be helpful in monitoring various parameters such as the consumption of fuel, and driver and vehicle performance. This provides a greater degree of visibility and helps speed up machine loadings and production to ensure timely customer deliveries. Shelf moving robots can be used to move the racks and shelves in the warehouse safely and systematically. The camera in the robots can scan the barcodes on each incoming item and move it to the designated shelves for further storage or packaging and dispatch (Blindenbach-Driessen 2010; Rehman et al., 2013). Firms face certain challenges in CE based operations (Batista et al., 2018). Such challenges can be overcome with proper supply chain planning (De Angelis et al., 2018). Digital procurement provides visibility and increasing resilience and overcome challenges in CE operations (Bag et al., 2020a). Therefore, we hypothesise:

H5: P4.0 has a positive impact on CE performance.

3.6 Productivity in Remanufacturing Operations and Circular Economy Performance

Remanufacturing activity involves using old/ second-hand components into new conditions (Kirchherr et al., 2017). Remanufacturing helps firms meet CE goals (economic prosperity, environmental quality and its influence on social equity) (Kirchherr et al., 2017). There are multiple ways of improving remanufacturing productivity. Proper planning and scheduling eliminate labour overtime hours and save monetary losses. The ability to manage a high number of remanufacturing production-related bills for materials can help the plant to run at its greatest capacity, leading to a high overall equipment effectiveness (Guide Jr et al., 2000; Guide Jr et al., 2003). Improving the hourly rate of unit production is a big achievement in remanufacturing operations (Savaskan et al., 2004). Moreover, this kind of shorter production cycle time compared to that of competitors provides firms with a competitive edge to firms. Increased remanufacturing productivity can restore the environment through a focus on environmental quality aspects and improving resource efficiency. Improved remanufacturing productivity also helps to reinforce the economy (Zhang 2018b). Therefore, we hypothesise:

H6: Improved productivity in remanufacturing operations has a positive impact on CE performance.

4. Research Design

4.1 Instrument Development

The present study acquires scale from the earlier published works and fits them to P4.0 perspective (refer to Table 8). Two experts from academia apart from the main researcher scrutinized every single item for content validity. Items not meeting the requirement of the current research were not considered in the questionnaire. To test the robustness of our conceptual model, the research team conducted a pilot study among 40 procurement managers who are professional members of Chartered Institute of Purchasing and Supply (CIPS), South Africa. All items in the questionnaire are measured using a five-point Likert scale, as it is very simple for the interviewer to read out the full list of scale descriptors and to analyse the data (Dahiru, 2008).

To avoid any kind of bias, this study attempts to control the firm age and firm size. Firm age refers to the number of years the firm has been operating since its establishment. The firm age is controlled by the ability of old firms to gather resources and reconfigure resources more easily than new firms. Old firms have a fully developed operations capability and an enhanced productivity performance in uncertain business environments (Fraccascia et al., 2019). The number of employees working in the organisation determines firm size. The number of employees present in an organisation is greater in larger firms. The resource levels are generally greater in larger firms (Gunasekaran et al., 2017).

4.2 Data Collection

The questionnaire was emailed to 350 working professionals having membership with CIPS. The samples were selected using convenience sampling technique. Eventually, the research team received 120 filled out questionnaires, indicating a response rate of 34.28 percent. The summary of respondents is provided in Table 1.

Table 1: Respondents Work Domain and Experience

Work Domain	**Work Experience**					
	Less than 5 years	6-10 years	11-20 years	21-30 years	Above 30 years	**Total**
Manufacturing/ Manufacturing related services	1	0	3	41	9	54
Automotive Component Manufacturers	0	2	3	30	10	45
Petrochemical	0	0	1	0	4	5
Mines and Quarries	0	0	0	5	1	6
Mineral processing	0	0	1	5	1	7
Education/ Research	0	0	0	1	0	1
Heavy Engineering	0	0	0	0	1	1
Electronic goods	0	0	0	0	1	1
Others	0	0	0	0	0	0
Total	1	2	8	82	27	120

Further to this, the research team conducted an analysis to discover the role of the respondent in the organisation and to assess the size (small, medium or large) of the organisation. The details in Table 2 indicate that maximum responses are received firstly from those at a Senior Vice President/Vice President level and secondly from medium size organisation with 301-500 employees.

Table 2: Different Organisational Roles and Employees' Strength

Role in the Organisation	**Number of Employees**					
	Less than 100	101-300	301-500	501-1000	More than 1000	**Total**
Board Member	0	0	1	0	1	2
CEO/President/Owner/ Managing Director	0	0	0	0	1	1
CFO/Treasurer/Controller	0	0	0	0	0	0
CIO/Technology Director	0	0	0	0	2	2
Chief Procurement Officer	0	0	2	3	6	11
Senior VP/VP	0	0	75	0	2	77
Head of Business Unit or Department	0	1	0	1	3	5
Manager	0	0	3	2	12	17
Data Analyst	0	0	0	0	1	1
Data Scientist	0	0	0	0	3	3
Consultant	0	0	0	0	0	0
Researcher	0	0	0	0	0	0
Others	0	0	1	0	0	1
Total	0	1	82	6	31	120

4.3 Non-response Bias

Email surveys with high/low response rates are criticised for non-response biases. The process of reducing non-response bias is to reduce the non-response itself during surveys. Three methods can be used to estimate non-response bias: comparing with identified values for the population; subjective approximation; and extrapolation. However, for checking non-response bias the research team compared wave 1 (data obtained within 30 days) and wave 2 (data obtained after 30 days; post sending of reminder). Statistical difference is assessed using Student's t-test with p-value $\leq$ 0.05 can be considered as statistically significant. The obtained p-value is 0.02 and therefore, no significant differences are found among both waves (Armstrong and Overton, 1977).

4.4 Common Method Bias (CMB)

The data is obtained from people working in the industry for long years and working in senior positions. The research team presented them with constructs on separate pages to minimise the item-priming effect. In addition, the survey instruments focus on objective measures meaning they can better ask questions that can be reliably be answered by a single respondent (Blindenbach-Driessen et al., 2010) and minimize effect of CMB (Fawcett et al., 2014; Flynn et al., 2018). Furthermore, Harman's single factor test indicates presence of seventeen factors, while the first factor explains maximum covariance (19.583%); which is lesser than fifty percent. We conclude that CMB does not impact our work (Podsakoff et al., 2003).

5. Data Analysis and Results

The PLS approach to performing SEM is used largely among researchers in the business management, information systems, and marketing sectors. Peng and Lai (2012) suggest the guidelines to be adopted for this technique in the area of operations management. The research team uses WarpPLS Version 6.0, the PLS based SEM for data analysis (Kock, 2016). After the data preparation stage, the pre-processed data is checked to verify if it is appropriate for PLS-based SEM analysis. The research team's checking confirms there are no missing values, no columns with zero variance, no identical column name, and no rank problem. Finally, all columns (indicators) were standardised. After this, the team proceeded with the path modelling and the results are presented below.

In Table 3, the model fit and quality indices are presented and found to be significant as the p-values are below 0.05. The Average block VIF and Average full collinearity VIF are within tolerable limits (Kock, 2016). The Tenenhaus GoF value indicates good fit and suitable for the study.

Table 3: Model Fit and Quality Indices

Model fit and quality indices	Values
Average path coefficient	0.197
Average R-squared	0.294
Average adjusted R-squared	0.278
Average block VIF	1.504
Average full collinearity VIF	2.578
Tenenhaus GoF	0.353

For verifying the corrections of the model, causality assessment indices are estimated, and the values are provided in Table 4. All values are within the acceptable level.

Table 4: Causality Assessment Indices

Causality Assessment Indices	Values
Sympson's paradox ratio	1.000
R-squared contribution ratio	1.000
Statistical suppression ratio	1.000
Nonlinear bivariate causality direction ratio	1.000

Nunnally and Bernstein (1994) suggested that the value of Cronbach's alpha to be at 0.70 or higher. Instrument reliability criteria is met in our study as all cases show values higher than 0.70 and the value of composite reliability is also more than the threshold value of 0.70. To check for the presence of multi-collinearity, the variance inflation factor (VIF) is referred to and all values are found to be below 5, which is good enough (Kock and Lynn, 2012). The value of latent variables considered in this study can be seen in Table 5.

Table 5: Latent Variable Coefficients

Latent variable coefficients	TAR	MAR	TER	PR	PRO	CEP	FA
R-squared	-	-	-	0.083	0.070	0.729	-
Adjusted R-squared	-	-	-	0.060	0.054	0.722	-
Composite reliability	0.761	0.802	0.706	0.096	0.804	0.841	1.000

Cronbach's alpha	0.654	0.724	0.381	0.495	0.730	0.790	1.000
Average variance extracted (AVE)	0.256	0.314	0.453	0.300	0.293	0.346	1.000
Variance Inflation Factor (VIF)	1.921	3.638	2.011	1.073	4.030	4.289	1.087

Discriminant validity criterion is satisfied in our case as all diagonal values in Table 6 are higher than rest of the values in the same respective column (Fornell and Larcker, 1981).

Table 6: Correlation among Latent Variable with Square Root of AVEs

	TAR	MAR	TER	PR	PRO	CEP	FA
TAR	**0.676**						
MAR	0.642	**0.860**					
TER	0.583	0.626	**0.673**				
PR	0.090	0.112	0.191	**0.548**			
PRO	0.591	0.798	0.597	0.156	**0.841**		
CEP	0.618	0.795	0.655	0.148	0.838	**0.888**	
FA	0.126	0.232	0.125	0.173	0.177	0.194	**1.000**

The uncertainty in the business environment brings several challenges for firms, which can be conquered through developing P4.0 and further achieving competitive advantage to sustain the CE. The study aspires to examine the impact of resources on P4.0 and further how P4.0 influences productivity in remanufacturing operations. Figure 4 demonstrates the tested model. The research team observes the following direct relationships viz: technological resources and P4.0; P4.0 and productivity in remanufacturing operations; productivity in remanufacturing operations and CE performance. The control variables, including firm size and firm age, which are considered in the model do not show any significant influence on productivity in remanufacturing operations outcome. The essence of RBV theory revolves around the fact that the ability of an organisation to obtain the optimal utilisation of its resources (in remanufacture operations) forms the foundation for attaining competitive advantage (refer to Figure 5). This assumption is supported by the opinion that every organisation has its USP (unique selling point) which cannot be easily imitated by other existing organisations. The present research conceptualises the involvement of various resources to achieve P4.0 that results in improved performance of CE.

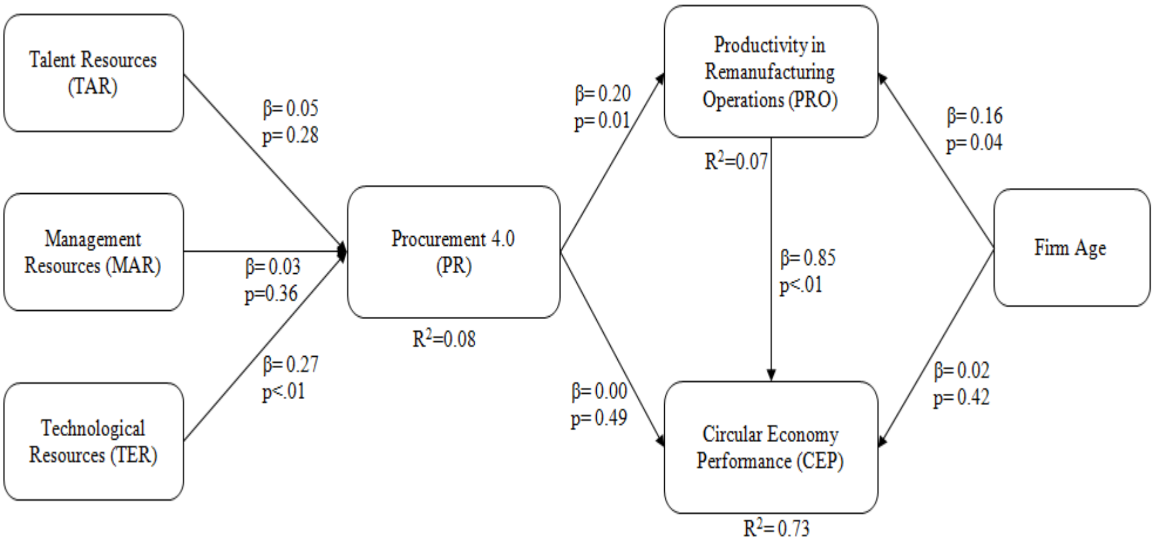

Figure 5: Theoretical Model after SEM Analysis

The received results clearly indicate the plausible success of organisations through adopting P4.0. The expertise required to remanufacture the products not only provides corporate sustainability, but also contributes towards social and environmental sustainability. On these grounds, it becomes highly essential for the organisations to relate to and understand importance of P4.0 and environmental uncertainty (refer to Figure 5) as it results into better CE.

The results are offered in Table 7. The beta values and p-values are provided for when deciding to either accept or reject the research hypothesis.

Table 7: Hypothesis Testing

Hypothesis	**Beta and p-value**	**Supported/Not Supported**
H1: Talent resources have a positive impact on P4.0	β = 0.05, p= 0.28	Not Supported
H2: Management resources have a positive impact on P4.0	β= 0.03, p= 0.36	Not Supported
H3: Technological resources have a positive impact on P4.0	β= 0.27, p<0.01	Supported

H4: P4.0 have a positive impact on productivity in remanufacturing operations	β= 0.20, p=0.01	Supported
H5: P4.0 have a positive impact on CE performance	β= 0.00, p= 0.49	Not Supported
H6: Productivity in remanufacturing operations have a positive impact on CE performance	β= 0.85, p<0.01	Supported

6. Discussion

Digital procurement can improve the business health by improving visibility and resilience. Increased visibility helps in material planning, thus significantly reducing lead times. A high degree of resilience can help firms to easily restore operations in the post-supply crisis stage. The idea of remanufacturing operations presents an alternative to sustainable manufacturing (Garetti et al. 2012); however, this suffers from great uncertainty due to the involvement of complex supply chain activities and multi-criteria decision-making (Linton et al. 2002). The uncertainty in both supply and demand can easily destroy any remanufacturing-based business if attention is not paid to strategies/methods for increasing visibility and resilience. Managing incoming supply of used parts (functional/non-functional) from multiple sources (global/local) is a complex process. Supply delay may happen due to delays of in-transit vessel, delays at port customs clearance, delays in road/rail transportation, goods received note (GRN) hold-ups due to commercial issues, incoming quality non-conformances, etc. Similarly, uncertainty in demand can also complicate the situation, leading to an increase in finished goods stock, thus creating blockage of working capital and creating temporary financial crisis. This also increases the risk of stock obsolescence with the changing technologies in the automotive and electronics market.

6.1 Theoretical Contributions

Drawing upon RBV theory, this study seeks to find a sustainable solution for remanufacturing firms through the development of resources to activating P4.0. The three research objectives are to firstly identify the resources essential to activating P4.0 and secondly to study the effect of P4.0 on remanufacturing productivity and CE performance. Our findings show that technological resources for using front and base technologies are essential to the activation of P4.0 systems. Such technological enablement must be carried out at the global manufacturing network, divisional level and functional level for the desired output. The results also reveal that P4.0 improves productivity in remanufacturing operations. This is possible by aligning the P4.0 plan with the company's mission and objectives. Any remanufacturing production suffers from uncertainty and risks. P4.0 systems provide increased visibility which will eliminate supply bottlenecks. Moreover, data availability on market intelligence and global supply pricing trends will provide buyers with the added advantage of being able to control supply chain costs in remanufacturing operations. With a high level of visibility, buyers can optimise energy, scarce natural resources, and procurement cycle time. Therefore, companies will be able to operate agile and customer-driven procurement in this volatile business environment and successfully run remanufacturing operations.

Another interesting finding from this study is that the productivity in remanufacturing operations leads to enhanced CE performance. The aim of CE is to enhance the longevity of resources through the use of the 3R principle (reduce, reuse and recycle). Optimisation of remanufacturing business process through P4.0 technological enablement can realise greater profit margins, shorter manufacturing cycle time, higher productivity and the elimination of wastages to further support CE. Pagoropoulos et al. (2017) suggest that digital technologies can aid in transforming firms from a linear to a CE and further support our finding that P4.0 digital technologies can indirectly enhance CE performance. Guide et al. (2003) talked about matching supply and demand to increase profits in remanufacturing business. P4.0 technological enablement can help to match supply with demand requirements and increase profit margins.

Increased innovations have intensified the level of market competition. This leads to frequent changes in production/service technology in the industry. The sales strategies also change based on the changes in products/services. Moreover, the environmental standards globally are also becoming stricter over time and affecting the sourcing/manufacturing and the disposal strategy of companies. P4.0 capability building can provide an edge to these manufacturing companies in an emerging economy like South Africa's. It can be concluded that the P4.0 system is suitable tool from a risk management perspective.

6.2 Managerial Implications

There are four key noteworthy points for managers and practitioners from this research. Firstly, managers need to focus on building technological resources in the organisation. Secondly, P4.0 must be a focus for improving remanufacturing operations productivity. Thirdly, remanufacturing operations productivity must be aligned with CE performance measures and strategies. However, what is very important for managers is to integrate the ERP, Manufacturing Execution System (MES) and Process Control Network (PCN) layer to form the re-manufacturing control architecture. The MES layer will get the details of the shop floor from the plant control layer and provide the same to the ERP layer. The ERP layer will further share the details with customers and suppliers. Finally, managers must emphasise the digital procurement policy for everybody in the organisation to be able to follow and adhere to the guidelines. The heads of both sales and operations need to sit together and discuss the sales forecast and plant capacity to finalise the Service Level Agreement (SLA) for all product lines. The SLA for all buyout items and the SLA for other raw materials must also be finalised and updated in the ERP system. Based on these details, ERP will carry out the remanufacturing production planning to meet customer dates. The reduction of wastage must be strictly monitored at each stage of the operations, as improved remanufacturing performance will attain CE objectives.

7.0 Conclusion and Future Research Directions

This research contributes to theory and practice by examining the key resources required in Procurement 4.0 environment for enhancing remanufacturing operations and circular economy performance in an emerging economy. To the best of our knowledge, our research work is unique in terms of scope and content, however, it is important to note that the study's sample size is not high in number and samples that are considered only from the perspective of companies operating in South Africa. The research team proposes an extension of this study to developed nations for the purpose of generalisability and to control variables such as investment pattern, environmental dynamism and the nature of the firms in future studies. Future studies could include an investigation of P4.0 technological resources in managing supply chain risks.

Appendix 1

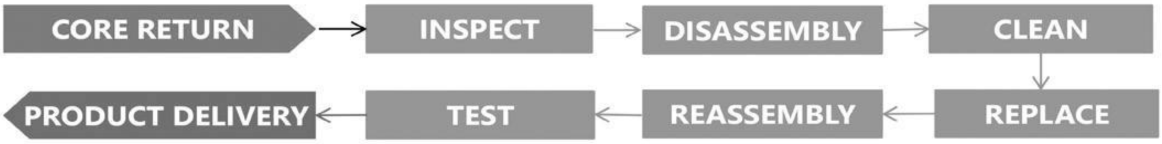

Figure 1: Generic Remanufacturing Process (Tjahjono and Ripant, 2019)

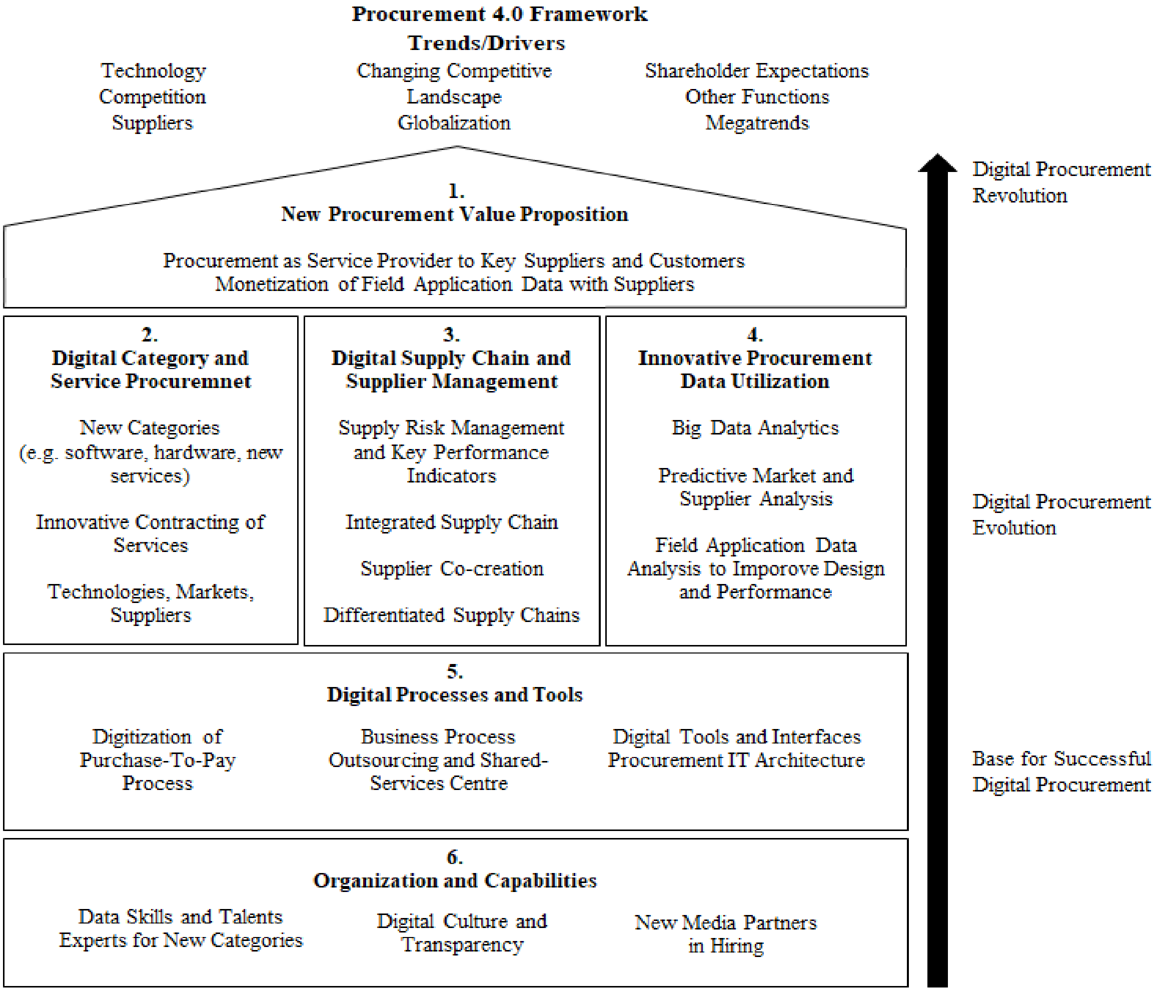

Figure 2: Procurement 4.0 Framework (Schrau and Berttram, 2016)

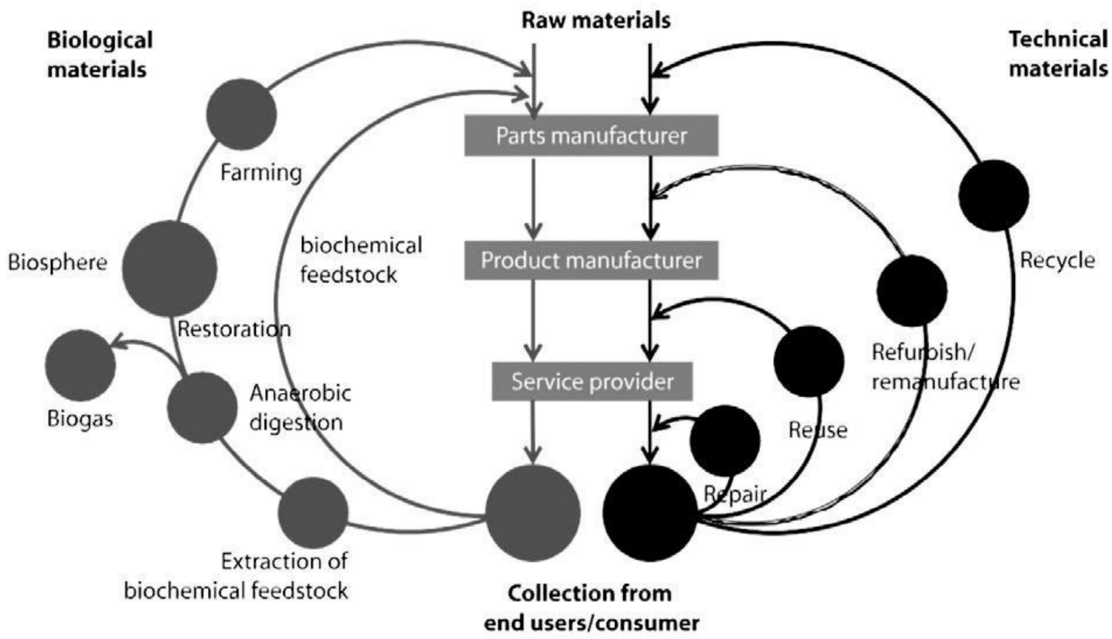

Figure 3: Circular Economy (Adapted from www.ellenmacarthurfoundation.org)

Table 8: Operationalization of Constructs

Latent Variable	Indicator	Measurement Constructs
Talent Resources (Adapted from Akter *et al.*, 2016)	**TAC1**	Our analytics personnel are capable in terms of programming skills
	TAC2	Our analytics personnel are capable in terms of managing project lifecycles
	TAC3	Our analytics personnel are capable in the areas of network management and maintenance
	TAC4	Our analytics personnel create every capable decision support system driven by analytics
	TAC5	Our analytics personnel show good understanding of technological trends
	TAC6	Our analytics personnel are knowledgeable about the critical factors for the success of our organization
	TAC7	Our analytics personnel are capable in interpreting business problems and developing appropriate technical solutions
	TAC8	Our analytics personnel are knowledgeable about business functions

	TAC9	Our analytics personnel are capable in terms of planning and executing work in a collective environment
	TAC10	Our analytics personnel work closely with customers and maintain productive user/client relationships
Technological Resources (Adapted from Frank *et al.*, 2019**)**	**TEC1**	All our plants located across different geographical regions have the capability to apply I4.0 front end technologies (smart supply chain, smart working, smart manufacturing, smart product) and base technologies (IoT, cloud, big data and analytics)
	TEC2	All divisions in our organisation have the capability to apply I4.0 front end technologies (smart supply chain, smart working, smart manufacturing, smart product) and base technologies (IoT, cloud, big data and analytics)
	TEC3	Our organization has capability to apply I4.0 front end technologies (smart supply chain, smart working, smart manufacturing, smart product) and base technologies (IoT, cloud, big data and analytics) at the functional level
Management Resources (Adapted from Akter *et al.*, 2016)	**MAC1**	We continuously examine innovative opportunities for strategic use of P4.0 systems
	MAC2	We enforce adequate plans for the introduction and utilization of P4.0 systems
	MAC3	We perform P4.0 planning processes in systematic and formalized ways
	MAC4	We frequently adjust P4.0 plans to better adapt to changing conditions
	MAC5	When we make P4.0 investment decisions, we think about and estimate the effect they will have on the productivity of the employees' work

	MAC6	In our organization, business analysts and line people from various departments frequently attend cross-functional meetings
	MAC7	In our organization, information is widely shared between business analysts and procurement team so that those who make decisions or perform jobs have access to all available know-how
	MAC8	We are confident that P4.0 project proposals are properly appraised
	MAC9	Our analytics department is clear about its performance criteria
Procurement 4.0 (Adapted from Bienhaus and Haddud, 2018)	**PRC1**	The P4.0 plan aligns with the company's mission, goals, objectives and strategies
	PRC2	The P4.0 plan contains detailed action plans/strategies that support company direction
	PRC3	Enhanced visibility results in arranging timely deliveries and avoidance of production delays
	PRC4	Data availability on market intelligence and global supply pricing trends results in procurement and manufacturing cost control
	PRC5	Our buyers can optimize energy, reconfigure resources and reduce procurement cycle time
	PRC6	Our company have integrated procurement into general management development and training programs
	PRC7	Our company have the ability to run agile and customer driven procurement
Productivity in Remanufacturing Operations (Adapted from Graham *et al.*, 2015)	**PRO1**	There is minimum bottleneck of input material availability
	PRO2	The margin in remanufactured product is high
	PRO3	The accuracy of quotations is high
	PRO4	The costing of cores and components in production

		are captured in SAP/ERP system
	PRO5	The number of design concessions are monitored strictly
	PRO6	Proper planning and scheduling have eliminated labour overtime hours
	PRO7	A high number of remanufacturing productions BOMs are managed successfully in the plant
	PRO8	The production cycle time is shorter than competitors
	PRO9	The number of unit production per hourly basis has improved
	PRO10	Overall equipment effectiveness is high
Circular Economy Performance **(**Adapted from Geng *et al.*, 2012; 2013**)**	**CEP1**	There is increased output of main mineral resource
	CEP2	There is increased output of energy
	CEP3	There is lower energy consumption per unit industrial production value
	CEP4	There is lower water consumption per unit industrial production value
	CEP5	There is lower energy consumption of per unit key product manufactured
	CEP6	There is lower water consumption of per unit key product manufactured
	CEP7	Recycling rate of industrial solid waste has improved significantly
	CEP8	Industrial water reuse ratio has improved significantly
	CEP9	Total amount of industrial solid waste for final disposal has decreased
	CEP10	Total amount of industrial wastewater discharge has decreased

References

Agrawal, S., R. K. Singh, and Q. Murtaza. 2015. "A literature review and perspectives in reverse logistics." Resources, Conservation and Recycling 9: 76-92.

Akter, S., S. F. Wamba, A. Gunasekaran, R. Dubey, and S.J. Childe. 2016. "How to improve firm performance using big data analytics capability and business strategy alignment?" International Journal of Production Economics, 182: 113-131.

Armstrong, J. S., and T.S. Overton. 1977. "Estimating nonresponse bias in mail surveys." Journal of Marketing Research 14 (3): 396-402.

Bag, S., S. Gupta, and C. Foropon. 2018a. "Examining the Role of Dynamic Remanufacturing Capability and Supply Chain Resilience in the Circular Economy." Management Decision Doi: 10.1108/MD-07-2018-0724.

Bag, S., A. Telukdarie, J.H.C. Pretorius, and S. Gupta. 2018b. "Industry 4.0 and supply chain sustainability: framework and future research directions." Benchmarking: An International Journal Doi: 10.1108/BIJ-03-2018-0056.

Bag, S., Wood, L. C., Mangla, S. K., and Luthra, S. 2020a. "Procurement 4.0 and its implications on business process performance in a circular economy." Resources, Conservation and Recycling, 152, 104502.

Bag, S., Wood, L. C., Xu, L., Dhamija, P., and Kayikci, Y. 2020b. "Big data analytics as an operational excellence approach to enhance sustainable supply chain performance." Resources, Conservation and Recycling, 153, 104559.

Barney, J., Wright, M., and Ketchen Jr, D. J. 2001. "The resource-based view of the firm: Ten years after 1991." Journal of Management 27(6): 625-641.

Barney, J. B. (2012). "Purchasing, supply chain management and sustained competitive advantage: The relevance of resource based theory." Journal of Supply Chain Management, 48(2): 3-6.

Batista, L., M. Bourlakis, Y. Liu, P. Smart, and A. Sohal. 2018. "Supply chain operations for a circular economy." Production Planning & Control 29 (6): 419-424.

Bharadwaj, A. S. 2000. "A resource-based perspective on information technology capability and firm performance: an empirical investigation." MIS Quarterly, 169-196.

Bienhaus, F., and A. Haddud. 2018. "Procurement 4.0: factors influencing the digitisation of procurement and supply chains." Business Process Management Journal 24 (4): 965-984.

Blindenbach-Driessen, F., J. Van Dalen, and J. Van den Ende. 2010. “Subjective Performance Assessment of Innovation Projects.” Journal of Product Innovation Management 27 (4): 572–592.

Bray Jr, C. E. 2019. “Doing It Right: Developing Procurement Talent for the 21st Century.” (Doctoral dissertation, Pepperdine University).

Brettel, M., N. Friederichsen, M. Keller, and M. Rosenberg. 2014. “How virtualization, decentralization and network building change the manufacturing landscape: An Industry 4.0 Perspective.” International Journal of Mechanical, Industrial Science and Engineering 8 (1): 37-44.

Brown, P. J., and C. Bajada. 2018. “An economic model of circular supply network dynamics: Toward an understanding of performance measurement in the context of multiple stakeholders.” Business Strategy and the Environment 27 (5): 643-655.

Chen, I. J., Paulraj, A., and Lado, A. A. 2004. “Strategic purchasing, supply management, and firm performance.” Journal of Operations Management 22(5): 505-523.

Choe, P., J. D. Tew, and S. Tong. 2015. “Effect of cognitive automation in a material handling system on manufacturing flexibility.” International Journal of Production Economics 170 (C): 891-899.

Croom, S. R. (2000). The impact of web-based procurement on the management of operating resources supply. Journal of Supply Chain Management 36(4): 4-13.

D’Addona, D. M., F. Bracco, A. Bettoni, N. Nishino, E. Carpanzano, and A.A. Bruzzone. 2018. “Adaptive automation and human factors in manufacturing: An experimental assessment for a cognitive approach.” CIRP Annals 67 (1): 455-428.

Datta, P. P. 2017. “Enhancing competitive advantage by constructing supply chains to achieve superior performance.” Production Planning & Control 28(1): 57-74.

Dahiru, T. 2008. “P-value, a true test of statistical significance? A cautionary note.” Annals of Ibadan Postgraduate Medicine 6 (1): 21-26.

De Angelis, R., M. Howard, and J. Miemczyk. 2018. “Supply chain management and the circular economy: towards the circular supply chain.” Production Planning & Control 29 (6): 425-437.

Dolgui, A., and M. A. Ould-Louly. 2002. “A model for supply planning under lead time uncertainty.” International Journal of Production Economics 78 (2): 145-152.

Dolgui, A., and J.M. Proth. 2013. “Outsourcing: definitions and analysis.” International Journal of Production Research 51 (23-24): 6769-6777.

Dubey, R., A. Gunasekaran, and A. Chakrabarty. 2015a. “World-class sustainable manufacturing: framework and a performance measurement system.” International Journal of Production Research 53 (17): 5207-5223.

Dubey, R., A. Gunasekaran, S. J. Childe, S.F. Wamba, and T. Papadopoulos. 2015b. “The impact of big data on world-class sustainable manufacturing.” The International Journal of Advanced Manufacturing Technology 84 (1-4): 631-645.

Dubey, R., A. Gunasekaran, S.J. Childe, S. Fosso Wamba, D. Roubaud, and C. Foropon. 2019. “Empirical investigation of data analytics capability and organizational flexibility as complements to supply chain resilience.” International Journal of Production Research Doi: 10.1080/00207543.2019.1582820

Dubey, R., A. Gunasekaran, S.J. Childe, T. Papadopoulos, Z. Luo, S.F. Wamba, and D. Roubaud. 2017a. “Can big data and predictive analytics improve social and environmental sustainability?.” Technological Forecasting and Social Change, Doi: 10.1016/j.techfore.2017.06.020.

Dubey, R., A. Gunasekaran, S. J. Childe, T. Papadopoulos, Z. Luo, and D. Roubaud. 2017b. “Upstream supply chain visibility and complexity effect on focal company’s sustainable performance: Indian manufacturers’ perspective.” Annals of Operations Research Doi: 10.1007/s10479-017-2544-x

Dubey, R., A. Gunasekaran, and S.J. Childe. 2018. “Big data analytics capability in supply chain agility: the moderating effect of organizational flexibility.” Management Decision Doi: 10.1108/MD-01-2018-0119.

Esposito, M., T. Tse, and K. Soufani. 2018. “Introducing a circular economy: new thinking with new managerial and policy implications.” California Management Review 60 (3): 5-19.

Fahimnia, B., J. Sarkis, and H. Davarzani. 2015. “Green supply chain management: A review and bibliometric analysis.” International Journal of Production Economics 162: 101-114.

Fawcett, S. E., M. A. Waller, J.W. Miller, M.A. Schwieterman, B.T. Hazen, and R.E. Overstreet. 2014. “A trail guide to publishing success: tips on writing influential conceptual, qualitative, and survey research.” Journal of Business Logistics 35 (1): 1-16.

Fay, A., B. Vogel-Heuser, T. Frank, K. Eckert, T. Hadlich, and C. Diedrich. 2015. “Enhancing a model-based engineering approach for distributed manufacturing automation systems with characteristics and design patterns.” Journal of Systems and Software 101: 221-235.

Flynn, B., M. Pagell, and B. Fugate. 2018. “Survey Research Design in Supply Chain Management: The Need for Evolution in our Expectations.” Journal of Supply Chain Management 54 (1): 1–15.

Fornell, C., and D. F. Larcker. 1981. “Evaluating structural equation models with unobservable variables and measurement error.” Journal of Marketing Research, 18 (1): 39-50.

Fraccascia, L., I. Giannoccaro, A. Agarwal, and E.G. Hansen. 2019. “Business models for the circular economy: Opportunities and challenges.” Business Strategy and the Environment, 28 (2): 430-432.

Frank, A. G., L.S. Dalenogare, and N.F. Ayala. 2019. “Industry 4.0 technologies: implementation patterns in manufacturing companies.” International Journal of Production Economics 210: 15-26.

Gandomi, A., and M. Haider. 2015. “Beyond the hype: Big data concepts, methods, and analytics.” International Journal of Information Management 35 (2): 137-144.

Garetti, M., and M. Taisch. 2012. “Sustainable manufacturing: trends and research challenges.” Production Planning & Control 23 (2-3): 83-104.

Gaustad, G., M. Krystofik, M. Bustamante, and K. Badami. 2018. “Circular economy strategies for mitigating critical material supply issues.” Resources, Conservation and Recycling 135: 24-33.

Geng, Y., J. Fu, J. Sarkis, and B. Xue. 2012. “Towards a national circular economy indicator system in China: an evaluation and critical analysis.” Journal of Cleaner Production 23 (1): 216-224.

Geng, Y., J. Sarkis, S. Ulgiati, and P. Zhang. 2013. “Measuring China's circular economy.” Science 339 (6127): 1526-1527.

Giret, A., D. Trentesaux, and V. Prabhu. 2015. “Sustainability in manufacturing operations scheduling: A state of the art review.” Journal of Manufacturing Systems 37 (1): 126-140.

Glas, A. H. and F. C. Kleemann. 2016. “The impact of Industry 4.0 on procurement and supply management: A conceptual and qualitative analysis.” International Journal of Business and Management Invention 5 (6): 55-66.

Geissdoerfer, M., P. Savaget, N.M. Bocken, and E.J. Hultink. (2017). The Circular Economy–A new sustainability paradigm?. Journal of Cleaner Production, 143: 757-768.

Ghisellini, P., and Ulgiati, S. 2020. "Circular economy transition in Italy. Achievements, perspectives and constraints." Journal of Cleaner Production 243: 118360.

Graham, I., P. Goodall, Y. Peng, C. Palmer, A. West, P. Conway, and F.U. Dettmer. 2015. "Performance measurement and KPIs for remanufacturing." Journal of Remanufacturing 5 (1): 1-17.

Guide Jr, V. D. R., R.H. Teunter, and L.N. Van Wassenhove. 2003. "Matching demand and supply to maximize profits from remanufacturing." Manufacturing & Service Operations Management 5 (4): 303-316.

Guide Jr, V. D. R. 2000. "Production planning and control for remanufacturing: industry practice and research needs." Journal of Operations Management 18(4): 467-483.

Guide Jr, V. D. R., Jayaraman, V., Srivastava, R., and Benton, W. C. 2000. "Supply-chain management for recoverable manufacturing systems." Interfaces 30(3): 125-142.

Guide Jr, V. D. R., Teunter, R. H., and Van Wassenhove, L. N. 2003. "Matching demand and supply to maximize profits from remanufacturing." Manufacturing & Service Operations Management *5*(4): 303-316.

Gunasekaran, A., T. Papadopoulos, R. Dubey, S.F. Wamba, S.J. Childe, B. Hazen, and S. Akter. 2017. "Big data and predictive analytics for supply chain and organizational performance." Journal of Business Research 70: 308-317.

Gupta, S., V.A. Drave, S. Bag, and Z. Luo. 2019. "Leveraging Smart Supply Chain and Information System Agility for Supply Chain Flexibility". Information Systems Frontiers Doi: 10.1007/s10796-019-09901-5.

Gupta, M., and George, J. F. 2016. "Toward the development of a big data analytics capability", *Information & Management*, 53(8): 1049-1064.

Hazen, B. T., D.A. Mollenkopf, and Y, Wang. 2017. "Remanufacturing for the circular economy: An examination of consumer switching behavior." Business Strategy and the Environment 26 (4): 451-464.

Hopkinson, P., M. Zils, P. Hawkins, and S. Roper. 2018. "Managing a complex global circular economy business model: opportunities and challenges." California Management Review 60 (3): 71-94.

Ivanov, D., A. Dolgui, and B. Sokolov. 2018. "The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics." International Journal of Production Research doi: 10.1080/00207543.2018.1488086

Isil, O., and M.T. Hernke. 2017. "The triple bottom line: A critical review from a transdisciplinary perspective." Business Strategy and the Environment 26(8): 1235-1251.

Jiang, Z., Ding, Z., Zhang, H., Cai, W., and Liu, Y. 2019. "Data-driven ecological performance evaluation for remanufacturing process." Energy Conversion and Management 198: 111844.

Jinhui Wu, S., and Closs, D. J. 2009. "The impact of integrating return components planning with purchasing decisions on purchasing performance: A contingency perspective." The International Journal of Logistics Management 20(1): 57-78.

Josserand, E., S. Kaine, and N. Nikolova. 2018. "Delivering sustainability in supply networks: Achieving networked multi-stakeholder collaborations." Business Strategy and the Environment 27(5): 605-611.

Kamble, S. S., A. Gunasekaran, and S.A. Gawankar. 2018. "Sustainable Industry 4.0 framework: A systematic literature review identifying the current trends and future perspectives." Process Safety and Environmental Protection 117: 408-425.

Katiyar, R., P.L. Meena, M.K. Barua, R. Tibrewala, and G. Kumar. 2018. "Impact of sustainability and manufacturing practices on supply chain performance: Findings from an emerging economy." International Journal of Production Economics 197: 303-316.

Katz-Gerro, T., and J. López Sintas. 2018. "Mapping circular economy activities in the European Union: Patterns of implementation and their correlates in small and medium-sized enterprises." Business Strategy and the Environment Doi: 10.1002/bse.2259

Khuan, L. S., and Swee, M. F. S. H. 2018. "Technologies for Procurement: Current Trends and Emerging Trends." Emerging Technologies for Supply Chain Management Ch 4: 45-61.

Kim, J. J. 2017. "Theoretical foundations underpinning supply chain management and supply chain level sustainable performance." International Journal of Tourism Sciences 17(3): 213-229.

Kirchherr, J., D. Reike, and M. Hekkert. 2017. “Conceptualizing the circular economy: An analysis of 114 definitions.” Resources, Conservation and Recycling 127: 221-232.

Kirci, M., and R. Seifert. (2015). “Dynamic capabilities in sustainable supply chain management: A theoretical framework.” In Supply Chain Forum: An International Journal 16 (4): 2-15.

Knudsen, D. 2003. “Aligning corporate strategy, procurement strategy and e-procurement tools.” International Journal of Physical Distribution & Logistics Management *33*(8): 720-734.

Kock, N. 2016. “Non-normality propagation among latent variables and indicators in PLS-SEM simulations.” Journal of Modern Applied Statistical Method 15 (1): 1-16.

Kock, N., and G. Lynn. 2012. “Lateral collinearity and misleading results in variance-based SEM: An illustration and recommendations.” Journal of Modern Applied Statistical Methods 15 (1): 299-315.

Kunz, N., K. Mayers, and L.N. Van Wassenhove. 2018. “Stakeholder views on extended producer responsibility and the circular economy.” California Management Review 60 (3): 45-70.

Kunz, N., and S. Gold. 2017. “Sustainable humanitarian supply chain management–exploring new theory.” International Journal of Logistics Research and Applications 20(2): 85-104.

Lamba, K., and S.P. Singh. 2017. “Big data in operations and supply chain management: current trends and future perspectives.” Production Planning & Control 28 (11-12): 877-890.

Lau, H. C., and Lee, W. B. 2000. “On a responsive supply chain information system.” International Journal of Physical Distribution & Logistics Management 30(7/8): 598-610.

Liebman, J. B., and N. Mahoney. 2017. “Do expiring budgets lead to wasteful year-end spending? Evidence from federal procurement.” American Economic Review 107 (11): 3510-49.

Lieder, M., and A. Rashid. 2016. “Towards circular economy implementation: a comprehensive review in context of manufacturing industry.” Journal of Cleaner Production 115: 36-51.

Linder, M., and M. Williander. 2017. “Circular business model innovation: inherent uncertainties.” Business Strategy and the Environment 26 (2): 182-196.

Linton, J. D., J. S. Yeomans, and R. Yoogalingam. 2002. "Supply planning for industrial ecology and remanufacturing under uncertainty: a numerical study of leaded-waste recovery from television disposal." Journal of the Operational Research Society 53 (11): 1185-1196.

Low, J. S. C., and Y.T. Ng. 2018. "Improving the economic performance of remanufacturing systems through flexible design strategies: A case study based on remanufacturing laptop computers for the Cambodian Market." Business Strategy and the Environment 27(4): 503-527.

Luthra, S., and Mangla, S. K. 2018. "Evaluating challenges to Industry 4.0 initiatives for supply chain sustainability in emerging economies." *Process Safety and Environmental Protection*, 117: 168-179.

Macchion, L., A. Da Giau, F. Caniato, M. Caridi, P. Danese, R. Rinaldi, and A. Vinelli. 2018. "Strategic approaches to sustainability in fashion supply chain management." Production Planning & Control 29(1): 9-28.

Manogaran, G., V. Vijayakumar, R. Varatharajan, P.M. Kumar, R. Sundarasekar, and C.H. Hsu. 2018. "Machine learning based big data processing framework for cancer diagnosis using hidden Markov model and GM clustering." Wireless Personal Communications 102 (3): 2099-2116.

Masurel, E. 2007. "Why SMEs invest in environmental measures: sustainability evidence from small and medium-sized printing firms." Business Strategy and the Environment 16 (3): 190-201.

Merkert, R., C. Mulley, and M.M. Hakim. 2018. "Trade-offs between transaction cost, operation cost and innovation in the context of procurement and asset specificity–The example of the bus industry." Research in Transportation Economics 69: 173-179.

Mikalef, P., Pappas, I. O., Krogstie, J., and Giannakos, M. 2018. "Big data analytics capabilities: a systematic literature review and research agenda." Information Systems and e-Business Management, 16(3): 547-578.

Mikalef, P., Pateli, A., Batenburg, R., and van de Wetering, R. 2013. "Investigating the impact of procurement alignment on supply chain management performance." Procedia Technology, 9: 310-319.

Mikalef, P., Pateli, A., Batenburg, R., and van de Wetering, R. 2014. "Business alignment in the procurement domain: a study of antecedents and determinants of supply chain performance." International Journal of Information Systems and Project Management, 2(1): 43-59.

Moktadir, M. A., Ahmadi, H. B., Sultana, R., Liou, J. J., and Rezaei, J. 2020. "Circular economy practices in the leather industry: A practical step towards sustainable development." Journal of Cleaner Production 251:119737.

Nicoletti, B. 2018. "The future: procurement 4.0." In *Agile Procurement* (pp. 189-230). Palgrave Macmillan, Cham.

Niranjan, S., S.R. Spulick, and K. Savitskie. 2018. "Mediating and moderating influencers of firm performance: Supply chain managers' perspective." Journal of Enterprise Information Management 31 (1): 38-63.

Nunnally, J. C., and I.H. Bernstein. 1994. "The theory of measurement error." Psychometric Theory, 3: 209-247.

Oh, S., Yang, H., and Kim, S. W. 2014. "Managerial capabilities of information technology and firm performance: role of e-procurement system type." International Journal of Production Research 52(15): 4488-4506.

Pagoropoulos, A., D.C. Pigosso, and T.C. McAloone. 2017. "The emergent role of digital technologies in the Circular Economy: A review." Procedia CIRP 64: 19-24.

Peng, D. X., and F. Lai. 2012. "Using partial least squares in operations management research: A practical guideline and summary of past research." Journal of Operations Management 30 (6): 467-480.

Perey, R., S. Benn, R. Agarwal, and M, Edwards. 2018. "The place of waste: Changing business value for the circular economy." Business Strategy and the Environment 27 (5): 631-642.

Podsakoff, P. M., S.B. MacKenzie, J.Y. Lee, and N.P. Podsakoff. 2003. "Common method biases in behavioral research: A critical review of the literature and recommended remedies." Journal of Applied Psychology 88 (5): 879-903.

Prieto-Sandoval, V., M. Ormazabal, C. Jaca, and E. Viles. 2018. "Key elements in assessing circular economy implementation in small and medium-sized enterprises." Business Strategy and the Environment 27 (8): 1525-1534.

Rakovska, M. A., and S.V. Stratieva. 2018. "A taxonomy of healthcare supply chain management practices." In Supply Chain Forum: An International Journal 19 (1): 4-24.

Ravichandran, T., Lertwongsatien, C., and Lertwongsatien, C. 2005. “Effect of information systems resources and capabilities on firm performance: A resource-based perspective.” Journal of management information systems 21(4): 237-276

Rehman, S., M. A. Khan, T. A. Zia, and L. Zheng. 2013. “Vehicular ad-hoc networks (VANETs)-an overview and challenges.” Journal of Wireless Networking and Communications 3 (3): 29-38.

Savaskan, R. C., Bhattacharya, S., and Van Wassenhove, L. N. 2004. “Closed-loop supply chain models with product remanufacturing.” Management Science 50(2), 239-252.

Schiele, H., 2007. “Supply-management maturity, cost savings and purchasing absorptive capacity: Testing the procurement–performance link.” Journal of Purchasing and Supply Management 13 (4): 274-293.

Schrauf, S., and Berttram, P. 2016. “Industry 4.0: How digitization makes the supply chain more efficient, agile, and customer-focused.” Strategy&. Recuperado de https://www. strategyand. pwc. Com/media/file/Industry4. 0. pdf.

Sivarajah, U., Irani, Z., Gupta, S., & Mahroof, K. (2019). Role of big data and social media analytics for business to business sustainability: A participatory web context. *Industrial Marketing Management*.

Sivarajah, U., Kamal, M. M., Irani, Z., & Weerakkody, V. (2017). Critical analysis of Big Data challenges and analytical methods. *Journal of Business Research*, *70*, 263-286.

Tai, Y. M. 2013. “Competitive advantage impacts of direct procurement management capabilities and Web-based direct procurement system.” International Journal of Logistics Research and Applications 16(3): 193-208.

Teng, B. S., and Cummings, J. L. 2002. “Trade-offs in managing resources and capabilities.” Academy of Management Perspectives 16(2): 81-91.

Telukdarie, A., E. Buhulaiga, S. Bag, S. Gupta, and Z. Luo. 2018. “Industry 4.0 implementation for multinationals.” Process Safety and Environmental Protection 118: 316-329.

Tjahjono, B., and Ripanti, E. 2019. “Circular Economy–what does it mean for remanufacturing operations?” 2019(1): 5-7.

Vanegas, P., J.R. Peeters, D. Cattrysse, P. Tecchio, F. Ardente, F. Mathieux, and J. R. Duflou. 2018. “Ease of disassembly of products to support circular economy strategies.” Resources, Conservation and Recycling 135: 323-334.

Van Loon, P., and L.N. Van Wassenhove. 2018. “Assessing the economic and environmental impact of remanufacturing: a decision support tool for OEM suppliers.” International Journal of Production Research 56 (4): 1662-1674.

Wade, M., and Hulland, J. 2004. “The resource-based view and information systems research: Review, extension, and suggestions for future research.” MIS Quarterly, 28(1): 107-142.

Walker, D., and K. Hampson. (Eds.). 2008. “Procurement strategies: A relationship-based approach.” John Wiley & Sons. Victoria. Australia.

Waller, M. A., and Fawcett, S. E. 2013. “Data science, predictive analytics, and big data: a revolution that will transform supply chain design and management.” Journal of Business Logistics 34(2): 77-84.

Wang, G., Gunasekaran, A., Ngai, E. W., and Papadopoulos, T. 2016. “Big data analytics in logistics and supply chain management: Certain investigations for research and applications.” International Journal of Production Economics 176: 98-110.

Wang, M. M., and J.J. Wang. 2019. “How vendor capabilities impact IT outsourcing performance: An investigation of moderated mediation model.” Journal of Enterprise Information Management Doi: 10.1108/JEIM-07-2018-0167.

Wernerfelt, B. 1995. “The resource based view of the firm: Ten years after.” Strategic Management Journal 16(3): 171-174.

Williams, B. D., Roh, J., Tokar, T., and Swink, M. 2013. “Leveraging supply chain visibility for responsiveness: The moderating role of internal integration.” Journal of Operations Management 31(7-8): 543-554.

Zhang, M., F. Lettice, H.K. Chan, and H.T. Nguyen. 2018a. “Supplier integration and firm performance: the moderating effects of internal integration and trust.” Production Planning & Control 29 (10): 1-12.

Zhang, Y., S. Liu, Y. Liu, H. Yang, M. Li, D. Huisingh, and L. Wang. 2018b. “The ‘Internet of Things’ enabled real-time scheduling for remanufacturing of automobile engines.” Journal of Cleaner Production 185: 562-575.

Zhang, J., X. Chen, and C. Fang. 2018c. “Transmission of a supplier’s disruption risk along the supply chain: a further investigation of the Chinese automotive industry.” Production Planning & Control 29 (9): 773-789.

Zheng, F., J. He, F. Chu, and M. Liu. 2018. “A new distribution-free model for disassembly line balancing problem with stochastic task processing times.” International Journal of Production Research 1-13.