

Categorization of Supply Chain Sustainability Risks in SMEs: A Preliminary evidence from a Developing Country

Agung Sutrisno

Department of Mechanical Engineering
Sam Ratulangi University
Manado, Indonesia
agungsutrisno@unsrat.ac.id

Vikas Kumar

Bristol Business School
University of the West of England
Bristol, United Kingdom
Vikas.Kumar@uwe.ac.uk

Dwi Handayani

Department of Industrial Engineering
Universitas Islam Indonesia
Yogyakarta, Indonesia
dwihandayani@uii.ac.id

Rudi K. Arief

Department of Mechanical Engineering
Universitas Muhammadiyah Sumatera Barat
Bukit Tinggi, Indonesia
Rudi.arief@umsb.ac.id

Shinta Virhdian

Balai Besar Logam dan Mesin (BBLM)
Bandung, Indonesia
Shinta_va@yahoo.com

Charles Punuhsingon

Department of Mechanical Engineering
Sam Ratulangi University
Manado, Indonesia
Charles_punuhsingon@unsrat.ac.id

Abstract

Small and Medium Enterprises (SMEs) are an important contributor to the global economic growth. Nevertheless, owing to their lack of managerial capability to manage the impact of business uncertainty, they are prone to business failures. To prevent this situation, identification of risks affecting sustainability of SMEs and preparing appropriate risk mitigation strategies are important. Most of the previous supply chain risk management studies discussing the sustainability risks are focused mainly on large enterprises and fail to address this in the SMEs context. To address this research gap, this paper presents a preliminary study of the typology and categorization of supply chain sustainability risk faced by SMEs in the context of a developing country Indonesia. A preliminary survey to identify and categorize supply chain sustainability risk faced by Indonesian SMEs is accomplished by deriving sustainability risk dimensions and variables based on the triple bottom line concept. The study presents supply chain sustainability risk dimensions and variables from SMEs of various sectors. We have also identified opportunities for further study from this initial effort.

Keywords: Small and Medium Enterprises (SME), Sustainability Risk, Supply Chain, Triple Bottom Line.

1. Introduction

Contributing to more than 60% of the global domestic product in developed and developing countries (Khalique et al., 2014), Small and Medium Enterprises (SMEs) are the back bone of economic growth at both of developed and developing countries (Gunasekaran et al., 2013). Thus, maintaining sustainability of SME operation will imply to assure security of global economic growth. Similar to larger business enterprises, SMEs operate business with their tiers. In this regard, sustaining business operation of the SMEs within supply chain context is undoubtedly important. However, characterized by their limitations such as lack of educational and managerial capability and limited operational fund makes SMEs business prone to the business death. According to Tong et al., (2018) only 13% of the SMEs survives after 10 years of their business operating ages. On the other side, pressure from global customer, stakeholders and market pressures enforce business owner to implement sustainability initiative in running business with their networks (Sarpong et al., 2019). This situation demands the need to identify risk factors affecting sustainability that relevant sustainability mitigation strategies could be formulated. Despite this demanding situation, attention of researchers to improve understanding on risk management practices at SMEs supply chain context are rarely found (Verbano and Venturini, 2013), as most of earlier references on managing supply chain risks are focusing on large enterprises and in a developed economy settings (Lavastre et al., 2013), (Vijay et al., 2019), (Qazi and Gaudenzi, 2016), Ghadimi et al., (2019). The previous existing studies on managing supply chain risk management at SMEs environment by Ellengard (2008) and Faisal (2015) mostly focus on operational type supply chain risks. Evolving as an important risk factors affecting existential of businesses in yearly time horizon (Fahimnia et al., 2015), investigative efforts in managing sustainability risk of SMEs in developing country settings is very rare in reference databases. Motivated by scarcity of studies on supply chain risk management at SMEs level with a focus to sustainability risks and in developing county context, this study presents an initial investigative effort on categorization of supply chain sustainability risk in the context of SMEs in Indonesia. The goal of this study are two folds; first to categorize supply chain sustainability risk in the SMEs, and second to categorize degree of importance among sustainability risk dimensions in the context of SMEs in developing countries. The structure of this paper is in the followings, in section 2, overview and characteristics of the Micro-Small-and Medium Enterprises based on the Indonesian regulatory perspective is presented. This is followed by categorization of supply chain sustainability risk in section 3. Categorization of supply chain sustainability risks of some typical SMEs using case example of Indonesia is presented in section 4. Section 4 and 5 relates to findings and conclusions from this study.

2. Overview and Characteristics of the Micro-Small and Medium Enterprises in Indonesian Context

On the basis of geographic locations and legislative regulations, definition of micro, small and medium enterprises varies among countries (Smith and Watson, 2012). In Indonesia as one of developing countries, categorization of Small and Medium enterprises is based on assets and financial income. According to the Indonesian Act number 20 2008 on the small and medium enterprises, Small and Medium Enterprises are classified as depicted in Table 1.

Table 1. Categorization of SME According to Indonesia Act Number 20 2008 on Small and Medium Enterprises

SME Category	Criteria	
	Assets	Annual Income
Micro	Up to 50 Million IDR	Up to 300 Million IDR
Small	50 – 500 Million IDR	300 – 2,5 Billions IDR
Medium	500 -50 Billions IDR	2,5 Billions – 50 Billions IDR

Until 2016, the number of SMEs in Indonesia has reached almost 90% of the business players and contributing to 59% of the National Product Domestic Brutto (PDB) (Arsiwi et al., 2018). Similar to other developing countries, SMEs in Indonesia absorbs most of the work force (Kusumawadhani et al., 2018). From the business point of view, the business model of the SMEs in Indonesia consists of seven categories ranging from Trade, Processing Industries, Agricultures, Farming, Fisheries, Animal Breeding and services. Compared to large business enterprises in Indonesian settings, limitations impeding development of the Indonesian SMEs business are lack of access to financial institutions, short product life cycle, low market access and lack of competent human resources (Adawiyah, 2013).

3. Risk and Supply Chain Risk Management

Following Aven (2012), the term risk is connected to the occurrence of forthcoming events with uncertainty on the time of their occurrence and consequences in terms of uncertain modes and duration. In expressing the occurrence rate of those event, the probability occurrence which is based on the prior decision makers knowledge is used. In expressing the scale of risk event consequences, when the monetary data is obtainable, the cost basis impact assessment is used (Ahsen, 2008). Otherwise, decision makers usually use ordinal scale ranging from 1 to 10 or 10 to 100 with their corresponding linguistic interpretation scale. Emerging as a new research stream in supply chain management discipline, supply chain risk terminology has many interpretations (Ho et al., 2015). Despite varying existing definitions, the principle of supply chain management is consisting of identifying and categorizing risk events, evaluating criticality of the impact of their occurrences and finding relevant risk mitigation strategies and monitoring the impact of the implemented risk mitigations against critical risks (Dani and Deep,2009).

Supply chain risk management is a new discipline that has evolved of the need to assure smoothness of business process flows along its chains against the impact of business uncertainties. Emerging as a new research stream in the supply chain management area, supply chain risk management deals with collaborative effort among supply chain tiers intended to identify and manage risk with the ultimate goal to reduce vulnerability against risks and ensuring profitability and business continuation (Hudnukar et al., 2017). Depending on classification criteria, supply chain risk categories can be broken down into various type of risks. According to Louis and Pagel (2019), based on newness of the risk modes taken into consideration, supply chain risks are classified as ordinary and sustainability risks. Ordinary risks are typology of risk disruptive events having temporary impact on the operational aspect of the enterprises and usually having no impact to their existential. On the other hand, sustainability risks are any kind

of risks that operational, environmental and social implications and threaten the existential of firm business in the longer time horizon.

3.1. Classification of Supply Chain Sustainability Risks

Becoming the buzzword in nowadays business world since the release of a book entitle Our Common Future by Brundtland in 1987, sustainability can be defined as the ability to provide the need of future generation without losing capability to provide the need of current society. In its definition context, sustainability is closely related to the three pillars; economical, environmental and social. Economical pillar related to capability to provide the need of customers based on the economic context. Environmental and social context demands on the need to consider impact of operations against environments and societal aspects. In parallel with efforts to extend sustainability initiative outside the company, the term sustainable supply chain is coined and has emerged as a new research stream in supply chain management discipline. Basing on above mentioned definition, supply chain sustainability risks can be defined as any risk factors that have an impact on environments and society that could threaten the capability to provide the need of future generations

In order to gain success in sustainability risk mitigation strategies, identifying sustainability risk modes is the first important step. By knowing and categorizing supply chain sustainability risks will provide better understanding of conditions affecting the occurrence of risk events, their causes and relevant mitigation strategies. Classification of sustainability risk dimensions can be referred to the work of (Sutrisno et al., 2019)

Table 2. Typological of Sustainability Risk (Adopted from Sutrisno et al., 2019)

Risk Dimension	Example of Risk Variable
Reputational Risk	Defamation of company reputation
Competition Risk	Price war among competitors
Innovation Risk	Lack of innovation capability
Environmental Risk	The use of forbidden chemicals in producing goods
Social Risk	Riots, sexual harassment, the use of child labor, substandard working facility
Regulatory Risk	Non-Compliance with regulatory standard
Human Resources Risk	Loss of Talent, absenteeism
Security Risk	Theft, Vandalism, Riot
Political Risk	The change of governmental policy
Behavioral Risk	Opportunistic Behavior, Impatience, disobedience or any other negative habitual
Collaborative Risk	Information leakage, distrust among partners
Corruption Risk	Purchasing substandard quality of goods and services from partners at standard rate, misuse of funds and or authority for personal interest

4. Research Methodology

This study uses the following steps to undertake this research. In the first stage, SME criteria were selected for interview and observation based on criteria taken from the Indonesian Law on Small and Medium Enterprises as described in the previous part. In the second step, literature review on studies related to SMEs, supply chain risk assessment, and sustainability were conducted to identify dimensions and variables of supply chain sustainability risk to establish theoretical model that was used as reference points. This study follows the work of Gianakis and Papadopoulos (2016) on categorization of sustainability risk variables and dimensions. In the third stage, selection of sampling method and respondent criteria was determined. As large number of SMEs exist in Indonesia, it is impossible and very costly to undertake survey covering all SMEs. Considering this situation, a decision to conduct semi-structured interview was considered more appropriate to evaluate relevance of the previous supply chain sustainability variables in the context of developing country and identification of the type of sustainability risk modes being obtained from the SMEs. This preliminary study was conducted with the help of some SMEs from various business sectors in Indonesia with at least three years in existence. Ten SME owners were visited and interviewed using semi structured questionnaires. Questions involved information on the company data (business core, product type, age of business, gender of the respondents and level of education), typologies of sustainability risk they faced in their everyday business activities and kind of sustainability risks they perceived importantly affecting to sustainability of their businesses using linguistics interpretations such as high, medium, low and no risk at all. Interview sessions were accomplished on average of 1 hour.

5. Findings

Table 3 presents the profile of the respondents from SMEs that participated in semi-structured interviews.

Table 3. SME profile of the survey sample

Respondent profile	Business Core	Role	Level of Education	Age of Business (years)	Gender
Company 1 (C1)	Wooden handicraft	Owner	Secondary High School	15	Male
Company 2 (C2)	Wooden handicrafts	Owner	Master Degree	6	Male
Company 3 (C3)	Flower Farming	Operating supervisor	Senior High School	8	Female
Company 4 (C4)	Fish Breeding	Owner	Senior High School	6	Male
Company 5 (C5)	Traditional Clothing Manufacturer	Owner	Bachelor	8	Female
Company 6 (C6)	Ceramics Pottery Maker	Owner	Senior High School	20	Male
Company7	Wooden Furniture	Owner	Senior	15	Male

(C7)			High School		
Company 8 (C8)	Traditional Agriculture Utensils	Owner	Elementary School	10	Male
Company 9 (C9)	Snack	Store Manager	Senior High School	7	Female
Company 10 (C10)	Traditional Coffee roaster and distributor	Owner	Secondary High school	15	Male

5.1. Identification and Categorization of Sustainability Risks of the SMEs

In our initial study, three-dimensional sustainability risk variables namely environmental, economic and social risk dimensions are used as basis to determine typology of sustainability risk perceived by the respondents. Using semi structured interviews to the respondents, sustainability supply chain categories and their variables identified are presented in Table 4.

Table 4. Representation of dimensions, variables and typological of sustainability risk variables perceived by the SME practitioners

Supply Chain Risk Category	Supply Chain Risk Variable	SMEs type										Count
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	
Reputational Risk	Product Hygienic									x		1
	Short product life cycle risk	x	x			x						3
	Aesthetical (Packaging) risk									x	x	2
Regulatory Risk (Compliance Risk)	Product certification					x				x		2
	Governmental regulation	x	x	x				x	x		x	6
	Imported Products								x			1
Competition Risk	Price War among competitors	x	x	x	x	x	X	x	x	x	x	10
	Change of Customers preference	x	x	x	x	x	X	x	x	x	x	10
	Entrance of new competitors	x	x	x	x	x				x		6
	Business Information Leakage	x	x	x	x	x				x		6
	Imitating competitors' product	x	x			x	x	x		x		6
Innovation Risk	Lack Innovation Capability	x	x				x	x	x			5
	No sense of innovation initiative	x	x				x		x			4

Human Resource Risk	Scarcity of Talented People	x	x			x		x			x	5
	Hijacked Talents					x		x	x	x		4
Business Disruptions	Workers absenteeism	x	x	x	x	x	x		x	x		8
	Equipment obsolescence	x	x			x		x	x	x	x	7
	Equipment breakdown	x	x				x	x	x		x	6
	Water and electricity shortage	x	x	x	x	x	x	x	x	x	x	10
	spare part cannibalization											
Security Risk	Criminals act	x	x	x	x							4
Property Damage	Natural Disasters	x	x	x	x	x	x	x	x		x	9
Social Risk	Unethical Treatment of animals											
	Unfair salaries											
	The use of pirated software											
	Bribery											
	The use of children workforce				x				x			2
	Ignorance on working place comfort	x	x	x	x	x	x	x	x	x	x	10
	Ignorance on using working safety apparatus	x	x	x			x	x	x		x	7
	Discrimination											
Environmental risk	Noise							x				1
	The use of forbidden chemicals											
	Packaging waste											
	By product waste	x	x		x	x	x	x	x			7
	Emission											
Environmental accidents	x	x	x	x			x				5	
Economic Risk	Tax Avoidance	x	x		x		x	x	x			6
	Patent Infringement	x				x				x		3
	Price Fixing											
	Dishonesty					x						1
	Increasing fuel and electricity tariffs	x	x	x	x	x	x	x	x	x	x	10

In reputational risk dimension, short product life cycle risk is perceived as the most perceived sustainability risk. Price War and the Change of Customers' Preference emerged as the two

mostly perceived economic risk factors. Flagging governmental support and product certification are the two kinds of regulatory -related sustainability risks. Governmental regulations in this paper is concerned with the discontinued support by the government to provide monitoring of the effectiveness of training and other type of capability building activities for the SMEs. Low awareness of the SMEs in recognizing and adopting the Indonesian National Standard for product sold by the SMEs is the second important compliance risk causing difficulty in widening product market segment and impeding production quantities. In Competition Risk, Price War Among Competitors and The Change of Customers Preference are the two sustainability risk factors perceived by the respondents. Lack of Innovation Capability and the Scarcity of Talented People are two kinds of sustainability risk emerging from Innovation and Human Resource Risk category. Criminal Act and natural disasters are two kinds of risk emerged from security and property damage dimensions. In business disruption risk category, Water and Electricity Price Rate and Workers Absenteeism are two kinds of most perceived sustainability risk. In Social Risk category, Working Location Comfort and the Ignorance on Using Safety Apparatus are the two most perceived as sustainability risk. In Environmental Risk category, by product waste is becoming the most perceived sustainability risk. In Economic Risk category, Increasing Fuel and Electricity Tariffs, Tax Avoidance and Patent Infringement are the three types of sustainability risk.

5.2. Degree of Sustainability Risk Importance

Each of sustainability risk category is having different impact on business sustainability. Considering this situation, this study attempts to present on the degree of sustainability risk importance among the respondents and the result is presented in Table 5. Among the ten sustainability risk categories the top three sustainability risks are fallen into regulatory, economic and competition Risks.

Table 5. Degree of Sustainability Risk Importance

Number	Sustainability Risk Category	Rank of Risk Importance
1	Reputational Risk	6
2	Regulatory Risk	1
3	Competition Risk	3
4	Innovation Risk	7
5	Human Resource Risk	9
6	Business Disruption Risk	5
7	Property Damage	4
8	Social Risk	10
9	Environmental Risk	8
10	Economic Risk	2

Using a very few respondents, certainly the results reported by this initial study do not provide high robustness and must be used cautiously. In addition, this study only considers the perception of the SMEs practitioners' and exclude perception of other stakeholders such as the government. Nevertheless, as this study is a kind of preliminary investigative effort, extension of this initial study using larger respondents representing different SME business sectors in Indonesia will provide a clearer portrait of sustainability risk category and variables affecting business continuation of the SMEs in the context of developing country.

6. Conclusions

SMEs are prime movers of economic development in both of developed and developing countries. Nevertheless, in spite of their strategic role in widening opportunity for job creation and boosting economic growth, the fate of SMEs business is often ended with death, signaling the need to prevent this unwanted condition. To prevent this unintended situation, identifying risk affecting the existential of their business is important as it is becoming first step in making relevant risk prevention strategies. In this paper, an initial survey is presented to identify and categorize supply chain sustainability risk types in the Indonesian SMEs. Our initial findings indicate that priority to focus attention on improving SMEs sustainability is related to mitigate economics, regulatory and competition risks as those are perceived as the most important sustainability risks. Innovation risk although have impactful to sustain competitiveness of the SMEs in longer time horizon is not perceived as important risk. Opportunities for further study from this initial effort are viable in the following paths. In future research, a deeper study to understand relationship among sustainability risks and their hierarchy is important to provide appropriate mitigation strategy for the most important sustainability risk drivers. Additionally, scholars can also investigate what can be learnt from project and quality management disciplines on improving manageability of SMEs supply chain sustainability risk using vast arrays of quality and project management techniques and tools such as establishment of intelligent method to estimate sustainability level of the SMEs. Finally, future studies can focus on identifying relevant risk management tools to select sustainability risk mitigation strategies in the SMEs context as well as using business scanning tool such as SWOT Analysis that are missing in references.

Acknowledgements

The authors would like to acknowledge financial support from the Royal Academy of Engineering (RAE) for undertaking this study under Industry and Academia Partnership (IAPP-1/100033) project. The result of this study is the view of the authors and does not necessarily reflect the view of the research funder.

References

- Arsiwi, P., Adi, P.W., and Subhiyakto, E.R., Value chain analysis as improving method for grilled fish, *Industrial Engineering Journal of Sarjana Wiyata University*, Vol. 2, No.1, pp.34-43, 2018, (In Indonesian).
- Adawiyah, W.R., Factors constraining the growth of small and medium enterprise development : a case example of banyumas regency, *Journal of Economics - General Sudirman University*, 2013. Retrieved from <http://jp.feb.unsoed.ac.id/index.php/sca-1/article/viewFile/134/139>.
- Aven, T., The Risk concept: historical and recent development, *Reliability Engineering and System Safety*, Vol.99, pp.33-44, 2012.
- Aghapour, A.H., Marthandan, G., Fe, D.Y. G., and Zailani, S., Risk management process towards operation performance in supply chain management: a survey of manufacturing small and medium enterprises, *International Journal of Logistics Management*, Vol.27, No.1, pp. 78-114, 2017.

- Ahsen, V.A., Cost oriented fmea, *International Journal of Quality and Reliability Management*, Vol.5, Iss. 5, pp.466 -476, 2008.
- Dani, S. and Deep, A., Investigating risk management capability within UK food supply chain, retrieved from <https://pdfs.semanticscholar.org/4c34/5d19cd803faa6603aa9ed2233dde699aa9eb.pdf>, 2009.
- Ellegard, C., Supply risk management in a small company perspective, *Supply Chain Management: An International journal*, Vol.13, Iss.6, pp.412-434, 2008.
- Fahimnia, B., Tang, C.S, Davarzani, H., and Sarkis, J., Quantitative models for managing supply chain risk : a review, *European Journal of Operational Research*, Vol.247, pp.1-15, 2015.
- Faisal, M.N., Managing risk in small and medium enterprises using QFD approach, *International Journal of Operations Research and Information Systems*, Vol 4, No.1, pp.64-83, 2015.
- Ghademi, P., Wang, C., and Lim, M.K., Sustainable supply chain modeling and analysis: paste debate, present problems and future challenges, *Resources, Conservation and Recycling*, Vol.140, pp. 72-81, 2019.
- Giannakis, M., and Papadopoulos, T., Supply chain sustainability: a risk management approach, *International Journal of Production Economics*, Vol.171, Part 4, pp.455-470, 2016.
- Gunasekaran, A., Rai, B. K., and Griffin, M., Resilience and competitiveness of small and medium size enterprise: an empirical research, *International Journal of Production Research*, Vol.49, No.18, pp.5489-5509, 2011.
- Hudnukar, M., Deskhpande, S., Rathod, V., and Jakhyyar, S. K., Supply chain risk classification schemes: a literature review, *Operations and Supply Chain Management: An International Journal*, Vol.11, No.4, 182-191, 2017.
- Ho, W., Zheng, T., Yildiz, H., and Talluri, S., Supply chain risk management: a literature review, *International Journal of Production Research*, Vol 53, Iss.16, pp.5031 – 5069, 2015.
- Khalique, M., Isa, A.H.Md., Shaari, J.A.N., and Ageel, A., Challenges faced by the smes in Malaysia, *International Journal of Current Research*, Vol.3, Iss 6, pp.398-401, 2011.
- Kusumawardhani, D., Rahayu, A.Y., and Maksum, I.R. The role of government in MSMEs : the empowerment of msmes during the free trade era in Indonesia, *Australian Accounting, Business and Finance Journal*, Vol.9, No.2, pp.23-42, 2015.
- Louis, M., and Pagell, M., Categorizing supply chain risk: review, integrated typology and future research, revisiting supply chain risk, Zhidisin, G., and Henke, M. Eds, Springer. Series Online.
- Lavastre, O., Gunasekaran, A., and Spalanzani, A., Supply chain risk management in french companies, *Decision Support Systems*, Vol.52, pp.828-838, 2012.
- Sutrisno, A., Kumar, V., Handayani, D., Arief, R. K., Virdhian, S. K., and Punuhsingon, C., A classification and framework for measuring supply chain sustainability risk indices in small and medium enterprises, in *AIP Conference Proceedings,2097,031001*, 2019. Available at: <https://doi.org/10.1063/1.5098176>.
- Sarpong, S.S., Gupta, H., and Sarkis, J., A supply chain sustainability innovation framework and evaluation methodology, *International Journal of Production Research*, Vol.57, Iss. 7, pp.1990 – 2008, 2018.
- Smit, Y. and Watkins, J.A., A literature review of small and medium enterprises (SME) risk management practices in south africa, *African Journal of Business Management*, Vol.6, No.2, pp.6324-6330, 2012.

- Tong, P., Zhon, C., and Wang, H., Research of the survival and sustainable development of small and medium enterprises in China under the background of low carbon economy, *Sustainability*, Vol 11, pp.3-17, 2019.
- Vishnu, C.R., Shridharan, R., and Kumar, R. P.N., Supply chain risk management: models and methods, *International Journal of Management and Decision Making*, Vol.18, No.1, pp.31-75, 2019.
- Verbano, C., and Venturini, K., Managing risk in small and medium enterprises: a literature review and research agenda, *Journal of Technology Management and Innovation*, Vol.8, No.3, pp. 186-197, 2013.
- Qazi, A., and Gaudenzi, B., Supply chain risk management: creating an agenda for future research, *International Journal of Supply Chain and Operational Resilience*, Vol.2, No.1, pp.12-50, 2016.

Biography / Biographies

Agung Sutrisno is an assistant professor in the Department of Mechanical Engineering at Sam Ratulangi University, Manado, Indonesia. He earned B.E. in Metallurgical Engineering and M.Eng in Manufacturing Engineering from University of Indonesia in 1999 and 2001. His PhD Degree in Systems Management and Engineering obtained from Pukyong National University in 2012. He has published papers in peer reviewed conference and Journals. His research interests are in Quality and Reliability Management, Supply Chain and Operations Management and Sustainability Engineering.

Vikas Kumar is a Professor of Operations and Supply Chain Management and Director of Research at Bristol Business School, University of the West of England, UK. He holds a PhD degree in Management Studies from Exeter Business School, UK and a Bachelor of Technology degree in engineering from Ranchi University, India. He has published more than 170 articles in leading International journals and international conferences. He is Co-Founder and Editor of the Int. J. of Supply Chain and Operations Resilience and serves on the editorial board of several international journals. He has secured external research funding from various research agencies and generated income in excess of £1 million. His current research interests include sustainability, short food supply chains, and operational excellence.

Dwi Handayani is an assistant professor at Indonesian Islamic University (UII),Yogyakarta, Indonesia. She obtained her B.Eng Degree in Industrial Engineering from UII Yogyakarta. Her master and doctorate degree in Industrial Engineering is obtained from Gadjah Mada University. Her research interests are in simulation, project management risk management and humanitarian operations. She has published papers in peer reviewed journals and conferences.

Rudi K. Arief is a lecturer in Department of Mechanical Engineering, Muhammadiyah University, West Sumatera Indonesia. He obtained his bachelor and Master degree from Mercu Buana University,Indonesia. Currently he is pursuing his PhD degree in Manufacturing Engineering in International Islamic University, Malaysia. He has 12 years working experiences in oil and gas industries. His research interest is in additive and lean manufacturing.

Shinta Virdhian is a chairman of the R & D division in Balai Besar Logam dan Mesin, Indonesian Ministry of Industries, Bandung. She earned her bachelor degree in Metallurgical Engineering from University of Indonesia. She finished her master degree in materials engineering from TU Delft, Netherland. Her doctorate degree in Materials Engineering is obtained from Kyushu University, Japan. She has published publications in various journals and conference proceedings related to materials engineering.

Charles Punuhsingon is an assistant professor at Department of Mechanical Engineering, Sam Ratulangi University, Manado. He obtained his bachelor degree in Mechanical Engineering from Sam Ratulangi University in 1996. His master degree in Industrial Engineering is obtained from Bandung Institute of Technology in 20005. His

PhD degree in Intelligent Manufacturing is obtained from Pukyong National University in 2015. His research interests are in intelligent manufacturing and Production Management