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The Industrial Revolution 4.0 and Entrepreneurial Orientation with Innovation as Mediation Effect on the Performance of Malaysian Furniture Industry: A Proposed Framework

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Abstract

As global competition between industries and countries intensifies, demand for processors to increase productivity, production and service quality continues to grow. This requires a versatile organization and the right tools to develop more efficient processes, reduce costs and increase productivity. The continuous development of global technology will affect the way customers behave, think and perceive value. Virtually all stages of change experienced by the manufacturing sector are modeled on human needs and growing customer demand. The manufacturing era is facing a new era of this ever-changing and challenging environment, often referred to as the Fourth Industrial Revolution. In the complex and changing business world, innovation and entrepreneurship have become key concepts for sustainable economic development. Economic, social and environmental sustainability are critical to organizational performance. This paper developed on the concept of previous research on Industry 4.0, entrepreneurial orientation, innovation and firm performance. It is hoped that this research will help to open a new window in the Industry 4.0 and entrepreneurial orientation research.

Keywords
Industrial Revolution 4.0, Innovation, Entrepreneurial Orientation, sustainable development, performance.

1. Background of the research

In recent years, computer and information systems have employed new methods in industry and services (Al-nahhas, 2019; Gerrikagoitia *et al.* 2019; WEF 2019). Evolution, this trend is the fourth trend in industrial systems: Industry 4.0. It is often called the Fourth Industrial Revolution. The term "Industry 4.0" has been largely used in the German scientific literature (Brettel *et al.* 2014; Sendler, 2018; Kagermann *et al.* 2015; Bauernhansl *et al.* 2014; Kagermann, 2013 and Burmeister *et al.* 2015). Research on Industry 4.0 is highly related to phenomena such as "Internet of Things", "Industrial Internet", "Internet of Services", "Data and Services", "Smart Factory 4.0", "Advanced Manufacturing" and "Smart Manufacturing" etc. and their investigation (Al-nahhas, 2019; Kagermann *et al.* 2015; Vermesan & Friess, 2013; Porter & Heppelmann, 2015; Westerlund *et al.* 2014; Simonite, 2014; Tvaronavičienė, 2014 and Rezk *et al.* 2015). This research uses the terms "Industry 4.0" and "Industrial Revolution 4.0" interchangeably.

The central idea behind the industrial revolution trend is to ensure that people in a given region have high-tech manufacturing sites, job opportunities and benefits to create a competitive advantage (Ramsauer, 2013; Avigdor *et al.* 2014; Arnold, 2017; Al-nahhas, 2019; Kiel, 2017 and Gerrikagoitia *et al.* 2019). The Internet appeared before the concept and beginning of the Fourth Industrial Revolution. Now it's about creating complex networks of intelligent

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machines, systems, processes, production for customers and consumers via the Internet, transforming the real world into information systems (Magruk, 2016 and Kagermann, 2013).

Foray, *et al.* (2011), in this case, refers to intelligent specialization and structural change, which is not based on radical innovation but on adaptation to radical changes. Bringing novel information and knowledge for future old economic value, by using existing industrial public resources (such as R & D, engineering, manufacturing and other capabilities to support innovation) for new activities and new structural changes (Foray *et al.* 2011 and Rezk *et al.* 2015). As a result, in this context, it can be refer more to the incremental innovation (Gerlitz, 2015 and Kirzner, 1997), instead of radical innovations (Fagerberg *et al.* 2006 and Olaniyi & Reidolf, 2015). However, these innovations in Industry 4.0 are continuous, disruptive innovations (Christensen, 1997), and disruptive innovations are significantly different in value from previous innovations and may replace continuous innovations (Gerlitz, 2015). In this setting, Industry 4.0 can be assumed as an incremental process that can be responsible for incremental or fundamental market innovation and fetch new value to the markets and businesses.

It has been established that entrepreneurial orientation plays a vital role in the success of global entrepreneurs (Aziz *et al.* 2014). The entrepreneurial phenomenon is on the upsurge and ever growing (Gartner & Shane, 1995; Thornton, 1999; Aziz *et al*. 2014; Entebang, 2011; Sathe, 2004; McGrath & MacMillan, 2000 and Ireland *et al.* 2002). Entrepreneurial orientation refers to decisions about companies adopting strategies that are innovative, proactive, risk-taking, autonomous, and competitively aggressive (Gartner & Shane, 1995; Thornton,1999; Lumpkin & Dess, 1996; Cools & Van den Broeck, 2007 and Quince & Whittaker, 2003 and Joubert, 2007). Entrepreneurial orientation setting helps increase firm performance and predicts business growth and financial performance.

Since the Investment Incentive Act was promulgated in 1968, Malaysia has been one of the countries whose industry has changed from import-oriented industrialization to export-oriented industrialization (Page & Tarp, 2017). Though technological contradictions are expanding, industrial plans and a lack of human capital development policies, including schools and universities, and low human capital utilization have provided tacit foreign knowledge and hindered structural changes in the economy (Page & Tarp, 2017). Facts have proved that the "Action Plan for Industrial Technology Development (APITD)" is the axis leading Malaysia's transition to a developed country by 2020. The government is pushing Industry 4.0 through a series of initiatives developed by agencies such as Malaysia Digital Economy Corporation or MDEC (Akbar *et al.* 2017 and Abdullah *et al.* 2017). In the transformation of Industry 4.0, the skills required by the labor force are not the skills of machines and robots (Sendler, 2018). Therefore, ideally, human capital should have richer knowledge and skills than objects (Ramsauer, 2013).

The socio-economic importance of furniture industry is undeniable: 8% of Malaysia's GDP, it generates nearly $ 2.5 billion in foreign exchange and provides employment for the majority of the labor force (Akbar *et al.* 2017). The foremost concerns upstretched were the inability to advance competitiveness and the lack of technology and innovation (Ratnasingam, *et al.* 2013). However, in recent years, Malaysian furniture manufacturers have come under competitive pressure from other less expensive furniture manufacturers, especially China and Vietnam (Ratnasingam *et al*. 2013 and Akbar *et al.* 2017). Therefore, Malaysian furniture manufacturers must start developing new strategies to improve productivity, competitiveness and innovation (Akbar *et al.* 2013). Therefore, this situation has led researcher to study the problem in detail, provide possible solutions to pressing problems, support Industry 4.0, and promote the entrepreneurial culture in furniture manufacturing sector.

2. Research problem and Theory of Constraints

Furthermore, look at Malaysian entrepreneur manufacturing and technology innovation is limited by two main obstacles: education, training and government regulations (ADB, 2011). Like many other countries, Malaysia does not have an effective financial system to support entrepreneurship (Hofmann & Rüsch, 2017). According to ADB 2011, the most successful and fastest outcome of this transformation in Asia is the Republic of Korea. The Malaysian government needs to think about the future and participate in well-planned long-term policy courses (Liao, *et al.* 2018), which include: developing human capital levels through quality education, commitment to science, technology, and research and development, financing, and the next step phase of development, corporate activities and key policy frameworks based on competition and incentives for innovation (Asian Development Bank, 2011).

Constrains theory is well suited for entrepreneurial-oriented implementation. Industry 4.0 and innovation detect constraints that prevent companies from implementing and training employees. This is also a systematic way to identify and remove constrains from the manufacturing industry, so young Malaysians can be trained and can easily

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use Industrial Revolution 4.0 in the company. Lack of financial resources, insufficient staff skills, IT infrastructure, maturity stage, company size, and unwillingness to change are factors that affect the implementation of Industry 4.0 (Balasingham, 2016 and Plessis, 2017). With these assertions, one could conclude that it may be the best theory to explain the implementation of entrepreneurial orientation, industrial revolution 4.0 and innovation in furniture manufacturing sector in Malaysia.

In Southeast Asia, such as Vietnam, Myanmar and Thailand, they have transitioned to Industry 4.0 (Ganapathy-Wallace, 2017). Veera, (2018) believes that the adoption of Industry 4.0 in Malaysia is quite slow, as many of them still insist on using 2.0 and 2.5 systems. In terms of manufacturing technology, Malaysia is still in the early stages of automation (Ooi, *et al.* 2018; Bahrin, *et al.* 2016 and Montanus, 2016), reducing transport distances and Inventory (Bahrin *et al.* 2016). At a glance, the entrepreneurial orientation and innovation will prepare the today's young generation with the aspirations to become one of the high achieving nations in the world from the economy, innovations and humankind perspectives.

3. Research Gap

Most technologies that will have a significant impact on the world in five to ten years have limited use, and technologies that transform the world in less than fifteen years can exist as laboratory prototypes (Cascio & Montealegre, 2016 and Bostrom, 2015). Although many are still in the early stages of development (Oosthuizen, 2017; see Wagner & Hansen, 2005 and Cascio & Montealegre, 2016).

Therefore, the rapid growth of technological development and its widespread impact on life are undeniable. Chui, *et al.* (2015), stated that this makes entrepreneurs the center of public opinion, facilitating transformation and major challenges (Kose, 2016 and Chui *et al.* 2015). But how entrepreneurs should get ready for the future of index automation in all sectors of the economy? (Müller & Bostrom, 2016) How should entrepreneurs business practices evolve to deal with the early disruption of the organization and the related impact on social structure? Chui *et al.* (2015), believe that the impact of organizations and entrepreneurs is huge: from entrepreneurs to front-line managers, there is a need to redefine jobs and processes to ensure longevity.

In emerging countries such as Malaysia, utmost research on entrepreneurship and Industry 4.0 is constructed on small businesses (Cascio & Montealegre, 2016; Miller & Le Breton-Miller, 2011 and Ambad & Wahab, 2013). Essentially, the challenges faced by large companies are different from those faced by small businesses. This is usually due to the fact that the two types of companies have different design and management styles (Cascio & Montealegre, 2016 and Ambad & Wahab, 2013). The study found that the manufacturing and innovation strategies used by large and small businesses are also different (Wagner & Hansen, 2005; Zahra & Garvis, 2015 and Müller & Bostrom 2016). Accordingly, it is important to conduct separate studies on the mediating effect of innovation on entrepreneurial orientation, industry 4.0 and firm performance according to firm size. This is because it is questionable whether the results of studies on small firms can be generalized to larger firms.

4. Research aim and objectives

The fact that the population of Malaysia is at its youngest age is an indisputable fact. Therefore, to reach the status of a high-income country by 2050, a policy must be established to educate and train young people with business knowledge and entrepreneurial skills. The overall goal of this research is to develop a framework for furniture entrepreneurs through the inspiration of Industrial Revolution 4.0 and innovation. In this regard, the following objectives have been established in order to achieve the appropriate objectives of the research.

1) To determine the relationship between entrepreneurial orientation and firm performance in furniture manufacturing industry in Malaysia.
2) To analyze the effect of industrial revolution 4.0 and firm performance in Malaysian furniture manufacturing industry.
3) To examine the mediating influence of the innovation on entrepreneurial orientation and firm performance in furniture manufacturing industry in Malaysia.
4) To examine the mediating effect of the innovation on industrial revolution 4.0 and firm performance in Malaysian furniture manufacturing industry.
5) To establish a framework which shows the influence of entrepreneurial orientation and industrial revolution 4.0 through innovation mediation on firm performance?

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5. Research Methodology

The study will investigate the issue using a mix method study design. Since this is a mixed method survey, qualitative and quantitative data will be collected. After reviewing the relevant literature, the first stage of the research methodology involved designing data collection tools. This will involve the design and validation of interview plans and questionnaires for qualitative and quantitative research. After the research tools have been developed, the second step of the method will involve collecting qualitative and quantitative data from relevant research participants. The fourth step will involve analyzing the data collected. Analysis will be performed using Computer Assisted Data Analysis Software (CADAS). Qualitative data will be analyzed with the help of Nvivo software, while quantitative data will be analyzed using SEM (Structural Equation Modelling) software such as Smart PLS-SEM 3 and IBM Amos SEM. Descriptive statistics (analysis) will be directed using Statistical Package for Social Science (SPSS). The final stage of the process will involve the integration of qualitative and quantitative data to provide an overall view of the issues examined. A survey framework will then be developed based on the survey results.

6. Conceptual Framework

The conceptual model shows the nature and direction of the relationship between the potential second-order construct and the first-order construct and their measures. It is generally believed that constructions will produce behaviors captured by their indicators, which means that changes in constructions will cause changes in their indicators. Hardin, *et al.* (2008), stated that so the measured value is a reflection of the structure. Diamantopoulos & Siguaw, (2006), these suggestions should clearly indicate whether the structure is formative or reflective. Howell *et al.* (2007), criticized Baggozi's (2007) suggestion to use formative measures and strongly recommended the use of reflective measures. This is because the weights of formative measures depend on the specific outcome variables used to estimate them. Therefore, the meaning of formative measurement structures may vary from study to study and to external validity may pose a threat. Howell, *et al.* (2007), considers this a limitation to scientific progress and "flaw in theory testing".

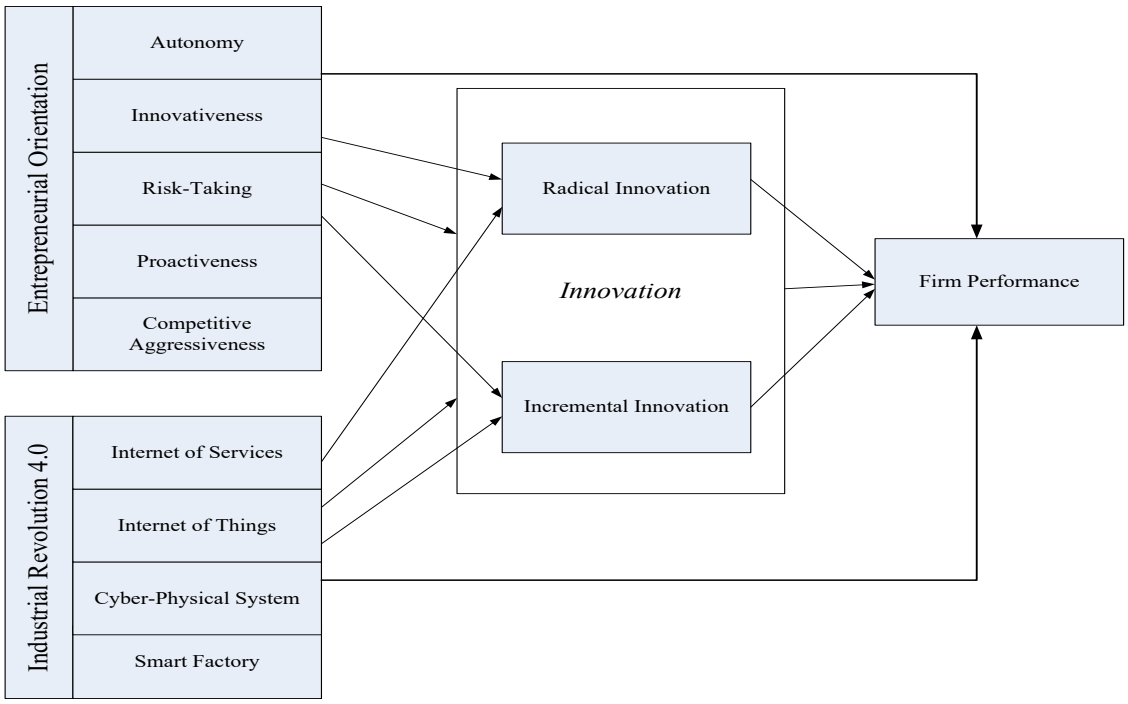

Figure 1: Conceptual Framework of the study, (Researcher, 2019)

Therefore, the relationships shown in the conceptual model in this study (figure 1) are specified as reflective measures of EO. Schillo, [64], also considered the five dimensions as reflection of a company's EO. The conceptual framework shows that EO is a second-order construct consisting of five first-order factors, namely innovativeness, autonomy, risk-taking, proactiveness and competitive aggressiveness which will be subsequently tested. Similarly, Industry 4.0

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is a second-order construct consisting of four first-orders constructs namely cyber-physical system, internet of services, internet of things and smart factory. Furthermore, the innovation is also a second-order construct which consist two first-order factors namely radical innovation and incremental innovation. To empirically test the conceptual framework, an appropriate methodology is essential and in line with research methodology, research tools that fit the purpose were identified and applied.

7. Discussion and Conclusion

Industrial Revolution 4.0, Entrepreneurship and innovation are closely linked which help companies to improve their performance. From product-centric business models to new models focused on creating and capturing new sources of value, global organizations are facing increasing pressure for change. As a result, innovation in this case becomes more complicated. In this context, people are increasingly aware of the need to interconnect and provide a different perspective on any global value chain: faster response capabilities and a manufacturing approach closer to customer needs. The focus of the study is known about the mediating effect of innovation on between the relationship of entrepreneurial orientation, industrial revolution 4.0 and firm performance of furniture manufacturing industry in Malaysia. Although there are many studies on entrepreneurial orientation and industry 4.0 involving the manufacturing sector, most research is conducted in industrialized (developed) countries. It is hoped this research will strengthen the existing Industry 4.0 knowledge system, as well as the entrepreneurial orientation and innovation of the furniture manufacturing industry in Malaysia, as well as its performance. It is expected that the results of this research will help government decision makers to help future research and implementation of Industry 4.0 through entrepreneurs focused on manufacturing to help industrial bases develop and produce products faster, cheaper and commercially viable. The study also hopes to make a practical contribution, focusing primarily on identifying industrialization-related issues that will help improve the sector's performance.

References

Abdullah, D. B., Abdullah, M. Y., & Salleh, M. A. M., *A Review on the Concept of Fourth Industrial Revolution and the Government ' S Initiatives To Promote It Among Youths in Malaysia.* Journal of Social Sciences and Humanities, 2(1), 1–8, 2017.

ADB. (2011). *Asia 2050: Realizing the Asian Century*. Singapore.

Akbar, F., Razak, A., Wadood, F., & Al-subari, S. N. A., *The Importance of Smes , And Furniture Manufacturing Smes in Malaysia : A Review of Literature.* International Journal of Business Management, *2*(4), 119–130, 2017.

Al-nahhas, N., Industry 4.0: 101 *– A Simplified Guide to the Fourth Industrial Revolution and its Application in the Oil and Gas Industry.* In AAPG Middle East Region, Shale Gas Evolution Symposium (Vol. 11, pp. 1–12). Bahrain: EnsoSoft Engineering & Software Solutions, Houston, Texas. http://doi.org/10.1306/70380Al-Nahhas2019

Ambad, S. N. A., & Wahab, K. A., *Entrepreneurial Orientation among Large Firms in Malaysia : Contingent Effects of Faculty of Business Management MARA University of Technology Islamic Science University of Malaysia*. International Journal of Business and Social Science, 4(16), 96–107, 2013a.

Ambad, S. N. A., & Wahab, K. A., *Entrepreneurial Orientation among Large Firms in Malaysia : Contingent Effects of Hostile Environments.* International Journal of Business and Social Science, 4(16), 96–107, 2013b.

Arnold, C., *The Industrial Internet of Things from a Management Perspective: A Systematic Review of Current Literature.* Journal of Emerging Trends in Marketing and Management, 2(2), 67–79, 2017.

Avigdor, G., Gauders, N., Hollanders, H., Lucas, R., Mielech, N., & Wintjes, R., *Smart Factories, Clean Tech and Customer Experience; How to scale-up the success of learning with users? B*usiness Innovation Observatory, 12(3), 1–59. Retrieved from http://ec.europa.eu/DocsRoom/documents/13386/attachments/1/translations/en/renditions/native,2014

Aziz, R. A., Mahmood, R., Tajudin, A., & Abdullah, M. H., *The Relationship between Entrepreneurial Orientation and Business Performance of SMEs in Malaysia.* International Journal of Management Excellence, 2(3), 221–239. http://doi.org/10.17722/ijme.v2i3.96, 2014a.

Balasingham, K., *Industry 4.0: Securing the Future for German Manufacturing Companies*. University of Twente. Retrieved from http://essay.utwente.nl/70665/1/Balasingham_BA_MA.pdf, 2016.

Bauernhansl, T., Hompel, M. ten, & Vogel-Heuser, B., *Industrie 4.0 in Produktion, Automatisierung und Logistik*. (Q. Titelfoto, Ed.). München: Springer Fachmedien Wiesbaden.

Bostrom, N. (2015). *Superintelligence: Paths, Dangers, Stategies.* British Library Cataloguing in Publication, 2(1), 1–27, 2014.

Brettel, M., Friederichsen, N., Keller, M., & Rosenberg, M., *How Virtualization, Decentralization and Network*

© IEOM Society International

Building Change the Manufacturing Landscape: An Industry 4.0 Perspective. International Journal of Information and Communication Engineering, 8(1), 37–44, 2014.

Burmeister, C., Luettgens, D., & Piller, F. T., *Business Model Innovation for Industrie 4.0: Why the "Industrial Internet" Mandates a New Perspective on Innovation.* SSRN Electronic Journal, 2(2), 124–154. http://doi.org/10.1088/0253-6102/65/4/460, 2015.

Cascio, W. F., & Montealegre, R., *How Technology Is Changing Work and Organizations.* The Annual Review of Organizational Psychology and Organizational Behavior, 3(3), 349–375. http://doi.org/10.1146/annurev-orgpsych-041015-062352, 2016.

Christensen, C. M., *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. (P. and F. of H. College, Ed.). Boston: Harvard Business School Press, 1997.

Chui, M., Manyika, J., & Miremadi, M., *Four fundamentals of workplaceautomation.* McKinsey Quarterly, 29(3), 1–9. http://doi.org/10.1017/CBO9781107415324.004, 2015

Cools, E., & Van den Broeck, H., *The Hunt for the Heffalump Continues: Can Trait and Cognitive Characteristics Predict Entrepreneurial Orientation?* Journal of Small Business Strategy, 18(2), 23–41. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=ent&AN=32658287&site=ehost-live, 2007.

Diamantopoulos, A., & Siguaw, J. A., *Formative versus reflective indicators in organizational measure development: A comparison and empirical illustration.* British Journal of Management, 17(4), 263–282. http://doi.org/10.1111/j.1467-8551.2006.00500.x, 2006.

Entebang, H., *Entrepreneurial Orientation and Corporate Entrepreneurship Performance of Government-Linked Companies in Malaysia.* Queen's University Management School, 2(1), 1–47. http://doi.org/10.1360/zd-2013-43-6-1064, 2011.

Fagerberg, J., Mowery, D. C., & Nelson, R. R., *The Oxford Handbook of Innovation.* Oxford University Press, 3(5), 318–345, 2006.

Foray, D., David, P. a, & Hall, B. H., *Smart specialization: From academic idea to political instrument , the surprising career of a concept and the difficulties involved in its implementation.* Management of Technology & Entrepreneurship Institute, 1(3), 1–16. http://doi.org/10.1016/S2212-5671(13)00124-X, 2011.

Gartner, W. B., & Shane, S. A., *Measuring entrepreneurship over time.* Journal of Business Venturing, 10(4), 283–301. http://doi.org/10.1016/0883-9026(94)00037-U

Gerlitz, L. (2015). *Design for Product and Service Innovation in Industry 4.0 and Emerging Smart Society.* Journal of Security and Sustainability Issues, 5(2), 181–198. http://doi.org/10.1080/03057920903254972, 1995.

Gerrikagoitia, J. K., Unamuno, G., Urkia, E., & Serna, A., *Digital Manufacturing Platforms in the Industry 4 . 0 from Private and Public Perspectives*. Applied Sciences, 9, 1–12, 2019.

Hardin, A. M., Chang, J. C.-J., & Fuller, M. a., *Formative vs. Reflective Measurement: Comment on Marakas, Johnson, and Clay (2007).* Journal of the Association for Information Systems, 9(9), 519–534. http://doi.org/Article, 2008.

Hofmann, E., & Rüsch, M., *Industry 4.0 and the current status as well as future prospects on logistics.* Computers in Industry, 89, 23–34. http://doi.org/10.1016/j.compind.2017.04.002, 2017.

Howell, R. D., Breivik, E., & Wilcox, J. B., *Reconsidering Formative Measurement.* Psychological Methods, 12(2), 205–218. http://doi.org/10.1037/1082-989X.12.2.205, 2007.

Ireland, R. D., Kyratko, D. F., & Morris, M. H., *A health audit for corporate entrepreneurship: Innovation at all levels: Part II.* Journal of Business Strategy, 27(2), 1317. http://doi.org/10.1108/02756660610650019, 2002.

Joubert, M., *The Evaluation of the Skills of Informal Entrepreneurs in the Goldfields.* North-West University, Potchefstroom Campus, 1(1), 1–24, 2007.

Kagermann, H. (). *Change Through Digitization—Value Creation in the Age of Industry 4.0.* Management of Permanent Change, 2(8), 1–240., 2015.

Kagermann, H., Wahlster, W., & Helbig, J. (). *Securing the Future of German Manufacturing Industry Recommendations for Implementing the Strategic Initiative Industrie 4.0*, 2013.

Kiel, D. (). W*hat Do We Know About "Industry 4 .0" So Far?* International Association for Management of Technology, 2(May), 1–22, 2017.

Kirzner, I. M., *Entrepreneurial Discovery and the Competitive Market Process: An Austrian Approach.* Source Journal of Economic Literature, 35(1), 60–85, 1997.

Kose, U., *Book Review: "The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies.*" Journal of Multidisciplinary Developments, 1(1), 1–9, 2016.

Kurzweil, R., *The Singularity is Near: The Age of Intelligent Machines.* (H. DeLillo, Ed.) (1st ed.). London: Penguin Group (USA) Inc, 2008.

Liao, Y., Loures, E. R., Deschamps, F., Brezinski, G., & Venâncio, A. (. *The impact of the Fourth Industrial*

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Revolution: A Cross-Country/Region Comparison. Production, 28(2), 1–18, 2018.
Lumpkin, G. T., & Dess, G. G., *Clarifying the Entrepreneurial Orientation Construct and Linking it to Performance.* Academy of Management Journal, 21(1), 135–172, 1996.
M. Veera, P., *Industry 4.0: The future is here - Along The Watchtower | The Star Online. Retrieved January 26, 2018*, from https://www.thestar.com.my/opinion/columnists/along-the-watchtower/2017/09/06/industry-40-the-future-is-here-malaysia-cannot-afford-to-lag-in-a-world-facing-swift-exponential-cha/, 2017.
Magruk, A., *Uncertainty in the Sphere of the Industry 4.0 – Potential Areas to Research.* Business, Management and Education, 14(2), 275–291, 2016.
McGrath, R., & MacMillan, I. C., *The entrepreneurial mindset: Strategies for continuously creating opportunity in an age of uncertainty.* Research-Technology Management, 43(4), 1–6, 2000.
Miller, D., & Le Breton-Miller, I., *Governance, social identity, and entrepreneurial orientation in closely held public companies.* Entrepreneurship: Theory and Practice, 35(5), 1051–1076, 2011.
Montanus, M., *Business Models for Industry 4 . 0*. Delft University of Technology, 2016.
Müller, V. C., & Bostrom, N., *Future Progress in Artificial Intelligence: A Survey of Expert Opinion.* Fundamental Issues of Artificial Intelligence, 1(1), 1–19, 2016.
Olaniyi, E. O., & Reidolf, M., *Organisational Innovation Strategies in the Context of Smart Specialization.* Journal of Security and Sustainability Issues, 5(2), 213–227, 2015.
Ooi, K. B., Lee, V. H., Tan, G. W. H., Hew, T. S., & Hew, J. J., *Cloud computing in manufacturing: The next industrial revolution in Malaysia?* Expert Systems with Applications, 93, 376–394, 2018.
Oosthuizen, C., *Entrepreneurial intelligence: expanding Schwabs four-type intelligence proposition to meaningfully addrss the challenges of the fourth industrial revolution.* Proceedings of the 28th Annual Conference of the Southern African Institute of Management Scientists, 28(2), 370–383. Retrieved from http://mediachef.co.za/saims-2016/papers/SME4_Full.pdf, 2016.
Oosthuizen, J., *The Determinants of Fourth Industrial Revolution Leadership Dexterity: A Proposed Framework for 4Ir-Intelligence and Subsequent 4Ir Leadership Development.* Motivation and Emotion, 30(3), 243–259, 2017.
Page, J., & Tarp, F., *The Practice of Industrial Policy*. (John Page and Finn Tarp, Ed.) (First). New York: Oxford University Press, 2017.
Perkins, D. H., Rasiah, R., & Woo, W. T., *Explaining Malaysia's Past Economic Growth and Future Prospects* (No. 2). Kuala Lumpur, 2017.
Plessis, C. J. du., *A Framework for Implementing Industrie 4 . 0 in Learning Factories*. Stellenbosch University, 2017.
Porter, M., & Heppelmann, J. E., *How Smart, Connected Products Are Transforming Companies.* Harvard Business Review, (October), 1–38, 2015.
Quince, T., & Whittaker, H., *Entrepreneurial Orientation and Entrepreneurs' Intentions and Objectives.* ESRC Centre for Business Research, 91(271), 399–419, 2003.
Ramsauer, C., *Industrie 4.0 – Die Produktion der Zukunft.* President's Council of Advisors on Science and Technology, 3(1), 1–12, 2013.
Ratnasingam, J., Yoon, C. Y., Mohamed, S., & Kassim, R. M., *Quality expectations in the Malaysian wooden furniture industry: The foreign buyers perspective.* Journal of Applied Sciences. http://doi.org/10.3923/jas.2013.889.894, 2013.
Rezk, R. M. A., Ibrahim, H. H., Tvaronavičienė, M., Sakr, M. M., & Piccinetti, L., *Measuring of Innovation Activities in Egypt: the Case of Industry 1*. Entrepreneurship and Sustainability Issues, 3(1), 47–55, 2015.
Sathe, V., C*orporate Entrepreneurship:Top Managers and New Business Creation*. University Press, Cambridge, 2(5), 1–26, 2004.
Schillo, S., *Entrepreneurial Orientation and Company Performance: Can the Academic Literature Guide Managers?* Technology Innovation Management Review, 23(November), 20–25, 2011.
Sendler, U., *Industrie 4.0*. (München, Ed.)*Gabler Wirtschaftslexikon* (Herausgebe). Deutschland: Springer Vieweg. http://doi.org/10.1007/978-3-642-36917-9, 2018.
Sharmila Ganapathy-Wallace., *Making Industry 4.0 a reality for Malaysia* | Digital News Asia. Retrieved January 26, 2018, from https://www.digitalnewsasia.com/digital-economy/making-industry-40-reality-malaysia, 2017.
Simonite, T. (). *The Internet of Things.* MIT Technology Review, 96–103, 2014.
Tat, O. C., *The Challenges of Industry 4.0 for Small and Medium-Sized Enterprises (SMEs)*. Putrajaya, 2017.
Thornton, P. H., *The Sociology of Entrepreneurship*. Annual Review of Sociology, 25(1), 19–46, 1999.
Tvaronavičienė, M. (). *If Industrial Sector Development is Sustainable Lithuania Compared to the EU.* Enterepreneurship and Sustainability Issues, 3(1), 134–142, 2014.
Vermesan, O., & Friess, P., *Internet of Things Strategic Research and Innovation Agenda*. (M. RUGGIERI, Ed.)*River Publishers* (Vol. 291). Aalborg: River Publishers. http://doi.org/10.1038/scientificamerican1004-76, 2013.

© IEOM Society International

Wagner, E. R., & Hansen, E. N., *Innovation in large versus small companies: Insights from the US wood products industry.* Management Decision, 43(6), 837–850, 2005.
WEF and Mc & C, W. E. F., *Fourth Industrial Revolution Beacons of Technology and Innovation in Manufacturing* (No. 2). Geneva, 2019.
Westerlund, M., Leminen, S., & Rajahonka, M., *Designing Business Models for the Internet of Things.* Technology Innovation Management Review, 4(7), 5–14, 2014.
Zahra, S. A., & Garvis, D. M. (). *International corporate entrepreneurship and firm performance.* Journal of Business Venturing, 15(5–6), 469–492, 2015.

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Dr. Abdul Talib Bon Professor of Technology Management Department of Production and Operations Management Universiti Tun Hussein Onn Malaysia Teaching Factory Based Learning IR 4.0: New Paradigm in Engineering Education Dr. Abdul Talib Bon is Professor of Technology Management in Department of Production and Operations Management, Faculty of Technology Management and Business at the Universiti Tun Hussein Onn Malaysia. He has a PhD in Computer Science, which he obtained from the Universite de La Rochelle, France in the year 2008. His doctoral thesis was on topic Process Quality Improvement on Beltline Moulding Manufacturing. He studied Business Administration major in Quality Management at the master's level in the Universiti Kebangsaan Malaysia for which he was awarded the MBA in the year 1998. He's bachelor degree and diploma in Mechanical Engineering which his obtained from the Universiti Teknologi Malaysia. He received his postgraduate certificate in Mechatronics and Robotics from Carlisle, United Kingdom in 1997. He is Director of Teaching Factory and Manager of Centre for Technology (Furniture Innovation Technology) since 1 September 2016. Dr. Abdul Talib Bon has had over 30 year experience of teaching in higher learning education. Dr. Abdul Talib Bon has multidisciplinary research interests that encompass industrial engineering, quality management and production and operations management. His completed 17 research grant projects as project leader include applications of forecasting in industries. He has supervised more than 100 undergraduate and PhD research students. He has served as a reviewer for a number of engineering management conferences and journals as part of his expertise sharing initiatives. He had published more than 300 International Proceedings and International Journals and 8 books. He is also Fellow and President of Industrial Engineering and Operation Management Society (IEOMS, Malaysia), Professional Technologist of Malaysia Board of Technologists (MBOT), Council member of Management Science and Operation Research Society of Malaysia (MSORSM), member of International Association of Engineers (IAENG), member of Institute of Industrial Engineer (IIE), USA, member of International Institute of Forecasters (IIF), member of Technological Association of Malaysia (TAM) and associate member of Malaysian Institute of Management (AMIM).

Dr. Fazli Wadood is an Associate Professor, and Dean of Department of Business Administration at University of Buner Pakistan. He earned B.S. in Computer Science from University of Peshawar Pakistan, Masters in Business Administration from The University of Agriculture, Peshawar, Pakistan and PhD in Technology Management from Universiti Tun Hussein Onn Malaysia. He has published journal and conference papers on Strategic Management, Innovation and Marketing Management. He has taught courses in entrepreneurship, management and corporate entrepreneurship and innovation for engineers and business students. Dr Wadood has completed research projects with Universiti Tun Hussein Onn Malaysia (UTHM), Higher Education Commission of Pakistan (HECP), University of Buner Pakistan (UOB), and SMEs Corporation of Pakistan (SMEDA). He is member of the Alumni Board of Directors and has elected a member of the research and innovation department. His research interests include innovation, qualitative expertise in research, marketing, management. He is member of, SMEDA and IEEE.

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