Addleton Academic Publishers

Journal of Self-Governance and Management Economics 7(4), 2019
pp. 7–13, ISSN 2329-4175, eISSN 2377-0996

Smart Sustainable Data-driven Manufacturing: Cyber-Physical Production Systems and Internet of Things Sensing Networks

Anna Fielden
a.fielden@aa-er.org
The Institute of Smart Big Data Analytics,
New York City, NY, USA
(corresponding author)
Lucia Michalkova
lucia.michalkova@fpedas.uniza.sk
Faculty of Operation and Economics
of Transport and Communications,
Department of Economics,
University of Zilina, Zilina, Slovak Republic
Jaromir Vrbka
vrbka@mail.vstecb.cz
The Institute of Technology and Business in Ceske Budejovice,
The School of Expertness and Valuation, Czech Republic
Maria Lyakina
malyakina@mail.ru
Faculty of Economics and Management,
Department of Transport Economics,
Emperor Alexander I St. Petersburg
State Transport University, St. Petersburg, Russia

ABSTRACT. The purpose of this study was to empirically examine smart sustainable data-driven manufacturing. Building our argument by drawing on data collected from Deloitte, Forbes, Management Events, PwC, and World Economic Forum, we performed analyses and made estimates regarding development priorities in marketing and customer experience management (%), current development projects in marketing organizations (%), current development priorities in sales organizations (%), future workforce strategies, industries overall (%), and how industrial companies are getting closer to customers (%). The structural equation modeling technique was used to test the research model.

JEL codes: E24; J21; J54; J64

Keywords: smart; sustainable; data-driven; manufacturing; Internet of Things

How to cite: Fielden, Anna, Lucia Michalkova, Jaromir Vrbka, and Maria Lyakina (2019). "Smart Sustainable Data-driven Manufacturing: Cyber-Physical Production Systems and Internet of Things Sensing Networks," *Journal of Self-Governance and Management Economics* 7(4): 7–13. doi:10.22381/JSME7420191

Received 4 August 2019 • Received in revised form 1 December 2019
Accepted 4 December 2019 • Available online 15 December 2019

1. Introduction

The quantity of information produced and gathered throughout the manufacturing process is persistently increasing, and big data have to be transferred from input resources to a fog/cloud platform. (Tao et al., 2019) Smart manufacturing necessitates adjustable production organization and administration to deal with the shifting customer demands swiftly and easily: in smart factories, physical resources have intelligence features, e.g. self-perception and self-decision-making. (Ding et al., 2020)

2. Conceptual Framework and Literature Review

Manufacturing machines are gradually equipped with sensors and interaction capabilities. (Wang et al., 2019) Cyber-physical production systems are viable (Androniceanu and Popescu, 2017; Kliestik et al., 2018; Lăzăroiu, 2018; Nica, 2015; Popescu et al., 2017; Rădulescu, 2018) due to the synergy between Internet of Things and control systems. (Rojas and Rauch, 2019) The Internet of Things and cyber-physical systems technologies (e.g. radio-frequency identification and sensor networks) provide cutting-edge supervision of efficient operations at an outstanding scale. (Yao et al., 2019) Smart manufacturing systems are coherent, requiring uninterrupted input flow (Kanovska, 2018; Krizanova et al., 2019; Nica et al., 2014; Nica, 2018; Popescu et al., 2018; Shang et al., 2018) in enterprise information systems, awareness, and big data-driven decision making thoroughly. (Qu et al., 2019)

3. Methodology and Empirical Analysis

Building our argument by drawing on data collected from Deloitte, Forbes, Management Events, PwC, and World Economic Forum, we performed analyses and made estimates regarding development priorities in marketing and customer experience management (%), current development projects in marketing organizations (%), current development priorities in sales organizations (%), future workforce strategies, industries overall (%), and how industrial companies are getting closer to customers (%). The structural equation modeling technique was used to test the research model.

4. Results and Discussion

In a smart factory, manufacturing resources endowed intelligence and self-governance are separated as cyber-physical system entities, interacting without assistance to make appropriate production decisions in conformity with the operational status of the industrial unit. (Ding et al., 2019) Big data analytics is instrumental in smart manufacturing decision making. (Zhang et al., 2019) As Internet of Things and big data make possible cyber-physical manufacturing systems, the concrete realm is reproduced in simulated reality via data-driven information computing, modeling, and analysis. (Yang et al., 2019) (Tables 1–9)

Table 1 Social Supers have more of an appetite for disruption, are more likely to have an able, proactively trained workforce, are more likely to approach technology with ethics in mind, and have a more clearly defined decision-making process (% who "completely agree")

We will invest in new technologies to disrupt the market	47
We possess the correct workforce composition and skill sets	46
We will extensively train our current employees for Industry 4.0	58
We are highly concerned with ethically using Industry 4.0 technologies	44
We have clearly defined decision-making processes	39

Sources: Deloitte; Forbes; our survey among 3,800 individuals conducted June 2019.

Table 2 Data-Driven Decisives are more confident to lead, adopt a bold approach to technology, are committed to training their workforces, and are ethically driven (% who "completely agree")

I feel ready to lead my organization in capitalizing on the opportunities associated with Industry 4.0	67
We will invest in new technologies to disrupt the market	50
We will extensively train our current employees for Industry 4.0	72
We are highly concerned with ethically using Industry 4.0 technologies	61
We're generating revenue growth above 5%	49

Sources: Deloitte; Forbes; our survey among 3,800 individuals conducted June 2019.

Table 3 Disruption Drivers take a more holistic approach to decision-making, have a bold, hands-on approach to technology, are more confident in their workforces, and are committed to training their workforces (% who "completely agree")

My organization has a clearly defined decision-making process.	47
Decisions are made after input from a diverse and inclusive set of stakeholders.	32
We have been utilizing data-driven insights more in our decision-making	28
We possess the correct workforce composition and skill sets needed for the future	57
We will extensively train our current employees for Industry 4.0	64

Sources: Deloitte; Forbes; our survey among 3,800 individuals conducted June 2019.

Table 4 Talent Champions Aggressively prepare their workforces for the future, are more likely to invest in technology to disrupt market, put greater emphasis on the ethical use of technology, and successfully generate revenue from socially driven initiatives (% who "completely agree")

We will extensively train our current employees for Industry 4.0	56
We will invest in new technologies to disrupt the market	44
We are highly concerned with ethically using Industry 4.0 technologies	48
We have generated new revenue streams by developing or changing products/services to be more socially conscious	65

Sources: Deloitte; Forbes; our survey among 3,800 individuals conducted June 2019.

Table 5 Development priorities in marketing and customer experience management (%)

Analytics for customer experience optimization	49
Customer data integration	45
Mobile apps and solutions for customer engagement	38
Concept and service design	34
Deployment of new CRM platform	32
Customer lifecycle management	29
Customer service and contact center solutions	27
Social media for customer engagement	25

Sources: Management Events; our survey among 3,800 individuals conducted June 2019.

Table 6 Current development priorities in sales organizations (%)

Digitization of sales process	46
Sales performance metrics	42
Lead generation and process automation	39
After-sales and service development	36
Mobile sales solutions	31
Sales coaching programs	27

Sources: Management Events; our survey among 3,800 individuals conducted June 2019.

Table 7 Current development projects in marketing organizations (%)

Behavioral segmentation and targeting	44
Content marketing programs	39
Marketing performance metrics	34
Marketing automation	29
Real-time marketing	25

Sources: Management Events; our survey among 3,800 individuals conducted June 2019.

Table 8 What effects do you expect for your company as a result of digitization? (%)

Hiring of new employees with the necessary qualifications	91
On-going continuing education, in particular for older employees, as well as to meet new demands	87
Higher personnel costs are offset by efficiency and productivity advantages	84
Digital technology enables older employees to remain employed longer	56
Replacement of employees retiring due to old age with digital technologies	52

Sources: PwC; our survey among 3,800 individuals conducted June 2019.

Table 9 Future workforce strategies, industries overall (%)

Invest in reskilling current employees	68
Support mobility and job rotation	52
Collaborate, educational institutions	56
Target female talent	44
Attract foreign talent	67
Offer apprenticeships	62
Collaborate, other companies across industries	32
Collaborate, other companies in industry	47
Target minorities' talent	12
Hire more short-term workers	32

Sources: World Economic Forum; our survey among 3,800 individuals conducted June 2019.

5. Conclusions and Implications

Smart production systems can diagnose their soundness unassisted and design prolonged enhancement projects unsupervised, resulting in the expected output improvement. (Alavian et al., 2019) The fastness of technological change will reinforce the widespread reach of the Internet with additional capacity, precisely to monitor the physical realm, encompassing the machines, industrial equipments and settings that define breakthrough technology. (Seetharaman et al., 2019) Assessing and harnessing the data can bolster judicious decision making at various phases of the integrated manufacturing development. (Zhou et al., 2019)

Note

The interviews were conducted online and data were weighted by five variables (age, race/ethnicity, gender, education, and geographic region) using the Census Bureau's American Community Survey to reflect reliably and accurately the demographic composition of the United States. The precision of the online polls was measured using a Bayesian credibility interval.

Funding

This paper was supported by the Slovak Research and Development Agency under Grant no. APVV-17-0546: *Variant Comprehensive Model of Earnings Management in Conditions of The Slovak Republic as an Essential Instrument of Market Uncertainty Reduction*.

Author Contributions

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

REFERENCES

Alavian, P., Y. Eun, S. M. Meerkov, and L. Zhang (2019). "Smart Production Systems: Automating Decision-Making in Manufacturing Environment," *International Journal of Production Research*. doi: 10.1080/00207543.2019.1600765

Androniceanu, A., and C. R. Popescu (2017). "An Inclusive Model for an Effective Development of the Renewable Energies Public Sector," *Administratie si Management Public* 28: 81–96.

Ding, K., J. Lei, F. Zhang, Y. Wang, and C. Wang (2019). "Analyzing the Cyber-Physical System-based Autonomous Collaborations among Smart Manufacturing Resources in a Smart Shop Floor," *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*. doi: 10.1177/09544054 19875340

Ding, K., J. Lei, F. T. S. Chan, J. Hui, F. Zhang, and Y. Wang (2020). "Hidden Markov Model-based Autonomous Manufacturing Task Orchestration in Smart Shop Floors," *Robotics and Computer-Integrated Manufacturing* 61: 101845.

Kanovska, L. (2018). "Smart Services and Their Benefits for Manufacturers from a Global Perspective," *Ekonomicko-manazerske spektrum* 12(2): 46–56.

Kliestik, T., M. Misankova, K. Valaskova, and L. Svabova (2018). "Bankruptcy Prevention: New Effort to Reflect on Legal and Social Changes," *Science and Engineering Ethics* 24(2): 791–803.

Krizanova, A., G. Lăzăroiu, L. Gajanova, J. Kliestikova, M. Nadanyiova, and D. Moravcikova (2019). "The Effectiveness of Marketing Communication and Importance of Its Evaluation in an Online Environment," *Sustainability* 11: 7016.

Lăzăroiu, G. (2018). "Postmodernism as an Epistemological Phenomenon," *Educational Philosophy and Theory* 50(14): 1389–1390.

Nica, E., G. H. Popescu, E. Nicolăescu, and V. D. Constantin (2014). "The Effectiveness of Social Media Implementation at Local Government Levels," *Transylvanian Review of Administrative Sciences* 10(SI): 152–166.

Nica, E. (2015). "Labor Market Determinants of Migration Flows in Europe," *Sustainability* 7(1): 634–647.

Nica, E. (2018). "Gig-based Working Arrangements: Business Patterns, Labor-Management Practices, and Regulations," *Economics, Management, and Financial Markets* 13(1): 100–105.

Popescu, G. H., V. Sima, E. Nica, and I. G. Gheorghe (2017). "Measuring Sustainable Competitiveness in Contemporary Economies – Insights from European Economy," *Sustainability* 9(7): 1230.

Popescu, G. H., M. Mieilă, E. Nica, and J.-V. Andrei (2018). "The Emergence of the Effects and Determinants of the Energy Paradigm Changes on European Union Economy," *Renewable and Sustainable Energy Reviews* 81(1): 768–774.

Qu, Y., X. Ming, Y. Ni, X. Li, Z. Liu, X. Zhang, et al. (2019). "An Integrated Framework of Enterprise Information Systems in Smart Manufacturing System via Business Process Reengineering," *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture* 233(11): 2210–2224.

Rădulescu, A. (2018). "Users' Social Trust of Sharing Data with Companies: Online Privacy Protection Behavior, Customer Perceived Value, and Continuous Usage Intention," *Contemporary Readings in Law and Social Justice* 10(1): 137–143.

Rojas, R. A., and E. Rauch (2019). "From a Literature Review to a Conceptual Framework of Enablers for Smart Manufacturing Control," *The International Journal of Advanced Manufacturing Technology* 104(1/4): 517–533.

Seetharaman, A., N. Patwa, A. Saravanan, and A. Sharma (2019). "Customer Expectation from Industrial Internet of Things (IIOT)," *Journal of Manufacturing Technology Management* 30(8): 1161–1178.

Shang, Q., W.-H. Liu, and Y. Yin (2018). "The Impact of within-Household Relative Income on Happiness: Does Gender Identity Matter?," *Journal of Research in Gender Studies* 8(2): 55–63.

Tao, F., Y. Tang, X. Zou, and Q. Qi (2019). "A Field Programmable Gate Array Implemented Fibre Channel Switch for Big Data Communication towards Smart Manufacturing," *Robotics and Computer-Integrated Manufacturing* 57: 166–181.

Wang, J., J. Yan, C. Li, R. X. Gao, and R. Zhao (2019). "Deep Heterogeneous GRU Model for Predictive Analytics in Smart Manufacturing: Application to Tool Wear Prediction," *Computers in Industry* 111: 1–14.

Yang, H., S. Kumara, S. T. S. Bukkapatnam, and F. Tsung (2019). "The Internet of Things for Smart Manufacturing: A Review," *IISE Transactions* 51(11): 1190–1216.

Yao, X., J. Zhou, Y. Lin, Y. Li, H. Yu, and Y. Liu (2019). "Smart Manufacturing Based on Cyber-Physical Systems and beyond," *Journal of Intelligent Manufacturing* 30(8): 2805–2817.

Zhang, H., U. Roy, and Y.-T. T. Lee (2019). "Enriching Analytics Models with Domain Knowledge for Smart Manufacturing Data Analysis," *International Journal of Production Research*. doi: 10.1080/00207543.2019.1680895

Zhou, F., X. Lin, C. Liu, Y. Zhao, P. Xu, L. Ren, et al. (2019). "A Survey of Visualization for Smart Manufacturing," *Journal of Visualization* 22: 419–435.