Cognitive BPM: Business Process Automation and Innovation with Artificial Intelligence

Aleš Zebec1[0000-0003-4469-3665]

¹ University of Ljubljana, School of Economics and Business, Kardeljeva ploščad 17, SI-1000 Ljubljana, Slovenia ales.zebec@student.uni-lj.si

Abstract. Business Process Management (BPM) offers a structured and organized way of managing business operations. However, it is based on routines and rigid definitions that offer limited flexibility and automation options. Advances in Artificial Intelligence (AI) technology are creating new possibilities by making business processes cognitive. IT Business Value research suggests that the adoption of Cognitive Computing (CC) in BPM will improve performance. In addition, I argue this effect is mediated by automation and innovation of business processes. Research in this field is scarce. I will empirically address this research problem by firstly developing measurement scales for the adoption of CC in the BPM context (CBPM) and Business Process Automation (BPA). Secondly, I will conduct an overarching survey that explores the connection between CBPM and corporate performance (CP). My work will contribute to the academic discourse on IT Business Value research and provide insights into what outcomes managers can expect from CC and AI technology adoption in day-to-day business operations and what management strategies to employ.

Keywords: Cognitive BPM, Cognitive Computing, Artificial Intelligence, Machine Learning, Process Automation, Process Innovation, Process Performance, Corporate Performance, Intelligent Enterprises.

1 Introduction

Cognitive computing [1] is an umbrella term for new problem-solving models that mimic the cognitive capabilities of the human mind via autonomous reasoning and learning. The main goal of CBPM is automation [2]. The basic idea is to mine the data of business operations, monitor execution, gather information, and use this data to train the Cognitive System to automatically respond to business situations. With every new situation, the system learns and adapts. Ultimately, the system itself determines the next best action. This profoundly changes the existing process models [3], making them highly event-driven, adaptive, and strictly goal-oriented by autonomous planning and decision making [4]. The resulting improvements are reflected in business process innovation. With this approach, we move towards truly Intelligent Enterprises [5-7] in which data feeds intelligence, which in turn feeds process automation and innovation. My research addresses the question of to what extent CBPM improves performance and whether this effect is mediated by the automation [8-16] and innovation [17-27] of business processes. To this end, I build on a theoretical argument of IT Business Value research, examining the impact of information technology on performance. My theory is based on the Resource Based View (RBV) of the firm [28, 29] as a theoretical framework for the identification of IT resources impacting CP [30-32]. During the initial examination of the domain, it was discovered that very little literature exists on the topic. Based on a Systematic Literature Review (SLR), a lack of empirical research addressing the connection between CBPM (IT resource) and improved CP (performance) was identified.

To empirically examine the research problem, I will utilize a survey design. For the constructs of BPI, Business Process Performance (BPerf), and CP, I will use the existing measurement instruments developed in previous studies [33-45]. I am defining a new measurement scale for the constructs of CBPM and BPA because a comprehensive model or measurement instrument does not yet exist.

The results of the research will contribute to extant IT Business Value research literature that relies on RBV as a basis for further managerial research. It will provide empirical evidence if CBPM is noted to be an important strategic determinant of increased process and corporate performance, mediated by the automation and innovation of business processes. From a managerial standpoint, the results will provide insights into what outcomes managers can expect from the adoption of CC and AI technology in day-to-day business operations and what management strategies to employ to achieve performance gains.

2 Theoretical background and hypotheses

Wang [46] presented the idea of a cognitive approach, using AI to manage dynamic and complex processes. The concept of CBPM was introduced by Motahari-Nezhad and Akkiraju [47] as a new BPM paradigm encompassing all aspects of BPM that are impacted and enabled by CC. Roeglinger et al. [1] defined the key characteristics of CC in the BPM context. The advantages are derived from cognitive computing and AI technologies. The key ones are automation and improvement through innovation. Various IT Business Value research [31, 48-51] suggests a strong relation between IT resources and CP. Thus, I argue that CC is becoming an invaluable business resource for future engineering systems and has a positive effect on CP.

Marrella and Mecella [52, 53] identified automation as the key enabler of the reactivity and flexibility necessary for BPM. Various authors explored AI techniques [4, 54-56] as key automation drivers. I conclude that the key improvements presented by the adoption of CC in BPM come from automating business activities.

Hull and Motahari-Nezhad [3] define Cognitive Process Enablement as the enhancement of business processes at the underlying process modeling, incorporating the Plan-Act-Learn cycle. I argue this will result in business process innovations, as the concept refers to performing the business activity in a new, innovative way [57]. Thus, I posit that BPA and BPI serve as mediators between CBPM and CP. Prior research on BPM offers a more detailed perspective on the role of BPM in relation to CP [39, 43, 58, 59], suggesting that BPerf has the role of a mediator between BPM and CP. As a result, we obtain a more detailed view of CBPM influence on performance. I conclude that the same applies to the proposed model, and I formulate that BPerf has a mediating role and positively influences CP.

2.1 Research hypotheses

Relevant constructs, relationships, and the research hypotheses considered in this research are shown in Figure 1.

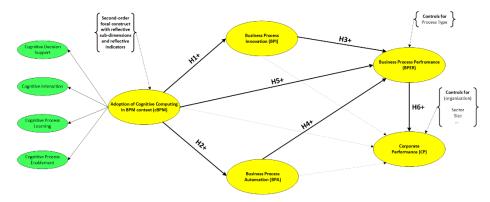


Fig. 1. Relevant constructs, relationships, and research hypothesis

3 Research design and methodology

The research will be carried out using a mixed-method approach, firstly by conducting exploratory research utilizing in-depth semi-structured interviews to discuss the topic with experts in the field.

Next, two new measures will be developed: CBPM adoption (second-order construct with reflective indicators) and BPA (first-order constructs with reflective indicators). Sub-dimensions of the CBPM adoption construct will be based on the four pillars of CBPM [3] (Decision Support, Interaction, Process Learning, and Cognitive Process Enablement) and merged with AI techniques classified by the CC characteristics proposed by Roeglinger et al. [1]. Items will be generated from the literature review and supplemented by insights and findings from the interviews, based on the procedure proposed by MacKenzie et al. [60] for construct development. An evaluation of content validity will follow the method suggested by Lawshe [61] with an expert panel, involving selected experts from industry and MIS academics. A pilot study will be conducted for the purifying and refining of the measurement. Reliability and factor analysis (EFA/CFA) will be used to assess the validity and internal consistency.

Developed measures for CBPM adoption and BPA will be merged with the existing measures for BPI, BPerf, and CP in a structured questionnaire. The developed

questionnaire will be used in the main survey to collect data. The sample for the main survey will consist of participants from the population of the EU companies using BPM/iBPM software with integrated AI technology in managing their processes. A sample size of at least 367 was defined. A control group of 25% will be included. Based on sample size and an optimistic 10% response rate, 3670 invites will be sent out. I will use random, probability sampling. If problems identifying respondents (hidden population) will arise, nonprobability snowball sampling will be used. A single primary data source, a single-source, self-report, and cross-sectional design will be used. The data will be collected through a questionnaire survey, and distributed by regular post and electronically. The questionnaire will be anonymous.

I will evaluate and control for non-response bias and common-method bias. To evaluate common-method bias, I will use Harman's single-factor test [62] and follow the recommendations for control by Podsakoff and MacKenzie [63]. Data analysis will be performed using SEM and mediation analysis by Hayes for testing a sequential multiple-mediator model [64].

4 State of the research

The research groundwork included SLR, developed research questions, derived hypothesis, and a theoretical conceptual model. SLR was based on the guidelines as proposed by Kitchenham [65, 66]. The search strategy was derived from an initial mapping study, identifying the topic scope and resources. I included literature from the fields of management, business, information system, and computer science. Resources included digital libraries, specific journals and conference proceedings focusing on BPM and AI.

A detailed action plan for construct development of CBPM and BPA with the initial set of scale items was prepared. An interview guide was developed, and three initial (of 15 planned) semi-structured interviews with academics and experts from the industry were conducted.

An analysis of AI techniques and algorithms with the potential of use in the context of BPM is currently in progress. An analysis of BPM software utilizing AI is in progress, focusing on Intelligent Business Process Management Suites (iBPM) implementations and Cognitive Services.

In the current stage of the research, some open points and issues have been identified, which I hope to resolve with the help of fellow academics and practitioners with experience in the field of BPM research.

Open points and issues:

- a.) feedback on the validity of the proposed sequential multiple-mediator model;
- b.) measurement/construct development: effectively capturing all the facets of AI usage in BPM, using second-order vs the first-order construct with linear composite (e.g., summated score) for CBPM, using formative model vs reflective for CBPM construct and removing CP construct from the model;
- c.) defining and sourcing eligible participants: conditioned with access;
- d.) conducting EU-wide research: translating of scales, scope, and accessibility.

References

- Roeglinger, M., Seyfried, J., Stelzl, S., Muehlen, M. zur: Cognitive Computing: What's in for Business Process Management? An Exploration of Use Case Ideas. In: Business Process Management Workshops. pp. 419–428. Springer International Publishing (2018)
- Fiedler, K.D., Grover, V., Teng, J.T.C.: Information technology-enabled change: the risks and rewards of business process redesign and automation. Journal of Information Technology. 9, 267–275 (1994). doi:10.1057/jit.1994.29
- Hull, R., Motahari Nezhad, H.R.: Rethinking BPM in a Cognitive World: Transforming How We Learn and Perform Business Processes. In: Lecture Notes in Computer Science. pp. 3–19. Springer International Publishing (2016)
- PHILLIPS-WREN, G.: AI TOOLS IN DECISION MAKING SUPPORT SYSTEMS: A REVIEW. International Journal on Artificial Intelligence Tools. 21, 1240005 (2012). doi:10.1142/s0218213012400052
- Quinn, J.B.: The intelligent enterprise a new paradigm. Academy of Management Perspectives. 19, 109–121 (2005). doi:10.5465/ame.2005.19417913
- Łobaziewicz, M.: The Role of ICT Solutions in the Intelligent Enterprise Performance. In: Information Technology for Management: New Ideas and Real Solutions. pp. 120–136. Springer International Publishing (2017)
- Repta, D., Moisescu, M.A., Sacala, I.S., Stanescu, A.M., Neagu, G.: Automated Process Mapping for Cyber Intelligent Enterprise. In: 2015 20th International Conference on Control Systems and Computer Science. IEEE (2015)
- Scheer, A.-W., Abolhassan, F., Jost, W., Kirchmer, M. eds: Business Process Automation. Springer Berlin Heidelberg (2004)
- Melchert, F., Winter, R., Klesse, M.: Aligning Process Automation and Business Intelligence to Support Corporate Performance Management. Proceedings of the Tenth Americas Conference on Information Systems. (2004).
- Sarnikar, S., Zhao, J.L.: Pattern-based knowledge workflow automation: concepts and issues. Information Systems and e-Business Management. 6, 385–402 (2007). doi:10.1007/s10257-007-0072-y
- Mendes, C., Silva, N., Silva, M., da Silva, M.M.: Automated Business Process Management. In: Lecture Notes in Business Information Processing. pp. 287–298. Springer International Publishing (2016)
- 12. Cognitive Business Operations: Processes and decisions that sense, respond, and learn. IBM Global Services (2016).
- Hamid, O.H., Smith, N.L., Barzanji, A.: Automation, per se, is not job elimination: How artificial intelligence forwards cooperative human-machine coexistence. In: 2017 IEEE 15th International Conference on Industrial Informatics (INDIN). IEEE (2017)
- Paschek, D., Luminosu, C.T., Draghici, A.: Automated business process management in times of digital transformation using machine learning or artificial intelligence. MATEC Web of Conferences. 121, 4007 (2017). doi:10.1051/matecconf/201712104007
- Rocha, G.S., Lacerda, D.P., Veit, D.R., Rodrigues, L.H., Dresch, A.: In the process babel: Definitions, concepts, and tools in a disordered field. Knowledge and Process Management. 24, 196–203 (2017). doi:10.1002/kpm.1543
- Sora, D., Leotta, F., Mecella, M.: An Habit Is a Process: A BPM-Based Approach for Smart Spaces. In: Business Process Management Workshops. pp. 298–309. Springer International Publishing (2018)
- Davenport, T.H.: Process innovation: reengineering work through information technology. Harvard Business School Press, Boston, MA (1992).

- Subramanian, A., Nilakanta, S.: Organizational innovativeness: Exploring the relationship between organizational determinants of innovation, types of innovations, and measures of organizational performance. Omega. 24, 631–647 (1996). doi:10.1016/s0305-0483(96)00031-x
- Tarafdar, M., Gordon, S.R.: Understanding the influence of information systems competencies on process innovation: A resource-based view. The Journal of Strategic Information Systems. 16, 353–392 (2007). doi:10.1016/j.jsis.2007.09.001
- Trantopoulos, K., von Krogh, G., Wallin, M.W., Woerter, M.: External Knowledge and Information Technology: Implications for Process Innovation Performance. MIS Quarterly. 41, 287–300 (2017). doi:10.25300/misq/2017/41.1.15
- Akgün, A.E., Keskin, H., Byrne, J.: Organizational emotional capability, product and process innovation, and firm performance: An empirical analysis. Journal of Engineering and Technology Management. 26, 103–130 (2009). doi:10.1016/j.jengtecman.2009.06.008
- Chen, J.-S., Tsou, H.-T.: Performance effects of IT capability, service process innovation, and the mediating role of customer service. Journal of Engineering and Technology Management. 29, 71–94 (2012). doi:10.1016/j.jengtecman.2011.09.007
- Das, S.R., Joshi, M.P.: Process Innovativeness and Firm Performance in Technology Service Firms: The Effect of External and Internal Contingencies. IEEE Transactions on Engineering Management. 59, 401–414 (2012). doi:10.1109/tem.2011.2157163
- Anand, A., Fosso Wamba, S., Gnanzou, D.: A Literature Review on Business Process Management, Business Process Reengineering, and Business Process Innovation. In: Lecture Notes in Business Information Processing. pp. 1–23. Springer Berlin Heidelberg (2013)
- Akgün, A.E., Keskin, H., Byrne, J.C., Lynn, G.S.: Antecedents and consequences of organizations' technology sensemaking capability. Technological Forecasting and Social Change. 88, 216–231 (2014). doi:10.1016/j.techfore.2014.07.002
- Yang, H., Yang, J.: The effects of transformational leadership, competitive intensity and technological innovation on performance. Technology Analysis & Strategic Management. 31, 292–305 (2018). doi:10.1080/09537325.2018.1498475
- González-Fernández, M., González-Velasco, C.: Innovation and corporate performance in the Spanish regions. Journal of Policy Modeling. 40, 998–1021 (2018). doi:10.1016/j.jpolmod.2018.05.005
- Wernerfelt, B.: A resource-based view of the firm. Strategic Management Journal. 5, 171– 180 (1984). doi:10.1002/smj.4250050207
- Burvill, S.M., Jones-Evans, D., Rowlands, H.: Reconceptualising the principles of Penrose's (1959) theory and the resource based view of the firm. Journal of Small Business and Enterprise Development. 25, 930–959 (2018). doi:10.1108/jsbed-11-2017-0361
- Santhanam, Hartono: Issues in Linking Information Technology Capability to Firm Performance. MIS Quarterly. 27, 125 (2003). doi:10.2307/30036521
- Melville, Kraemer, Gurbaxani: Review: Information Technology and Organizational Performance: An Integrative Model of IT Business Value. MIS Quarterly. 28, 283 (2004). doi:10.2307/25148636
- Ryu, H.-S., Lee, J.-N., Choi, B.: Alignment Between Service Innovation Strategy and Business Strategy and Its Effect on Firm Performance: An Empirical Investigation. IEEE Transactions on Engineering Management. 62, 100–113 (2015). doi:10.1109/tem.2014.2362765
- Wang, C.L., Ahmed, P.K.: The development and validation of the organisational innovativeness construct using confirmatory factor analysis. European Journal of Innovation Management. 7, 303–313 (2004). doi:10.1108/14601060410565056
- Hilmi, M.F., Ramayah, T., Mustapha, Y., Pawanchik, S., Ayub, M.A.: Strategic and Behavioral Innovativeness of Malaysian SMEs: Preliminary Results from a First Wave Data

6

Collection. The International Journal of Interdisciplinary Social Sciences: Annual Review. 5, 1–12 (2010). doi:10.18848/1833-1882/cgp/v05i08/51845

- Faroque, A.R., Morrish, S.C., Ferdous, A.S.: Networking, business process innovativeness and export performance: the case of South Asian low-tech industry. Journal of Business & Industrial Marketing. 32, 864–875 (2017). doi:10.1108/jbim-06-2015-0113
- Ng, H.S., Kee, D.M.H.: The core competence of successful owner-managed SMEs. Management Decision. 56, 252–272 (2018). doi:10.1108/md-12-2016-0877
- Akgün, A.E., Keskin, H., Byrne, J.: Organizational emotional capability, product and process innovation, and firm performance: An empirical analysis. Journal of Engineering and Technology Management. 26, 103–130 (2009). doi:10.1016/j.jengtecman.2009.06.008
- Akgün, A.E., Keskin, H., Byrne, J.C., Lynn, G.S.: Antecedents and consequences of organizations' technology sensemaking capability. Technological Forecasting and Social Change. 88, 216–231 (2014). doi:10.1016/j.techfore.2014.07.002
- Hernaus, T., Bosilj Vuksic, V., Indihar Stemberger, M.: How to go from strategy to results? Institutionalising BPM governance within organisations. Business Process Management Journal. 22, 173–195 (2016). doi:10.1108/bpmj-03-2015-0031
- Škrinjar, R., Bosilj-Vukšić, V., Indihar-Štemberger, M.: The impact of business process orientation on financial and non-financial performance. Business Process Management Journal. 14, 738–754 (2008). doi:10.1108/14637150810903084
- Škrinjar, R., Vukšić, V., Štemberger, M.: Adoption of Business Process Orientation Practices: Slovenian and Croatian Survey. Business Systems Research. 1, (2010). doi:10.2478/v10305-012-0022-0
- McCormack, K., Willems, J., van den Bergh, J., Deschoolmeester, D., Willaert, P., Indihar Štemberger, M., Škrinjar, R., Trkman, P., Bronzo Ladeira, M., Paulo Valadares de Oliveira, M., Bosilj Vuksic, V., Vlahovic, N.: A global investigation of key turning points in business process maturity. Business Process Management Journal. 15, 792–815 (2009). doi:10.1108/14637150910987946
- Hernaus, T., Pejić Bach, M., Bosilj Vukšić, V.: Influence of strategic approach to BPM on financial and non-financial performance. Baltic Journal of Management. 7, 376–396 (2012). doi:10.1108/17465261211272148
- Law, C.C.H., Ngai, E.W.T.: ERP systems adoption: An exploratory study of the organizational factors and impacts of ERP success. Information & Management. 44, 418–432 (2007). doi:10.1016/j.im.2007.03.004
- Wu, M.-S., Huang, S.-J., Chen, L.-W.: The preparedness of critical success factors of IT service management and its effect on performance. The Service Industries Journal. 31, 1219–1235 (2011). doi:10.1080/02642060903437014
- Wang, M., Wang, H.: From process logic to business logic—A cognitive approach to business process management. Information & Management. 43, 179–193 (2006). doi:10.1016/j.im.2005.06.001
- Motahari Nezhad, H.R., Akkiraju, R.: Towards Cognitive BPM as the Next Generation BPM Platform for Analytics-Driven Business Processes. In: Business Process Management Workshops. pp. 158–164. Springer International Publishing (2015)
- Cao, G. (2010). A four-dimensional view of IT business value. Systems Research and Behavioral Science, 27(3), 267–284. https://doi.org/10.1002/sres.1015
- Krishnamoorthi, S., & Mathew, S. K. (2018). Business analytics and business value: A comparative case study. Information & Management, 55(5), 643–666. https://doi.org/10.1016/j.im.2018.01.005

- Aydiner, A. S., Tatoglu, E., Bayraktar, E., Zaim, S., & Delen, D. (2019). Business analytics and firm performance: The mediating role of business process performance. Journal of Business Research, 96, 228–237. https://doi.org/10.1016/j.jbusres.2018.11.028
- Gregor, S., Martin, M., Fernandez, W., Stern, S., & Vitale, M. (2006). The transformational dimension in the realization of business value from information technology. The Journal of Strategic Information Systems, 15(3), 249–270. https://doi.org/10.1016/j.jsis.2006.04.001
- Marrella, A., Mecella, M.: Cognitive Business Process Management for Adaptive Cyber-Physical Processes. In: Business Process Management Workshops. pp. 429–439. Springer International Publishing (2018)
- Marrella, A.: What Automated Planning Can Do for Business Process Management. In: Business Process Management Workshops. pp. 7–19. Springer International Publishing (2018)
- Knoch, S., Herbig, N., Ponpathirkoottam, S., Kosmalla, F., Staudt, P., Fettke, P., & Loos, P. (2019). Enhancing Process Data in Manual Assembly Workflows. In Business Process Management Workshops (pp. 269–280). Springer International Publishing. https://doi.org/10.1007/978-3-030-11641-5 21
- Marshall, T. E., & Lambert, S. L. (2018). Cloud-Based Intelligent Accounting Applications: Accounting Task Automation Using IBM Watson Cognitive Computing. Journal of Emerging Technologies in Accounting, 15(1), 199–215. https://doi.org/10.2308/jeta-52095
- Klumpp, M. (2017). Automation and artificial intelligence in business logistics systems: human reactions and collaboration requirements. International Journal of Logistics Research and Applications, 21(3), 224–242. https://doi.org/10.1080/13675567.2017.1384451
- Turulja, L., & Bajgoric, N. (2019). Innovation, firms' performance and environmental turbulence: is there a moderator or mediator? European Journal of Innovation Management, 22(1), 213–232. https://doi.org/10.1108/ejim-03-2018-0064
- Kohlbacher, M. (2010). The effects of process orientation: a literature review. Business Process Management Journal, 16(1), 135–152. https://doi.org/10.1108/14637151011017985
- Miri-Lavassani, K., & Movahedi, B. (2018). Achieving higher supply chain performance via business process orientation. Business Process Management Journal, 24(3), 671–694. https://doi.org/10.1108/bpmj-07-2016-0140
- MacKenzie, Podsakoff, Podsakoff: Construct Measurement and Validation Procedures in MIS and Behavioral Research: Integrating New and Existing Techniques. MIS Quarterly. 35, 293 (2011). doi:10.2307/23044045
- Lawshe, C.H.: A quantitative approach to content validity. Personnel Psychology. 28, 563– 575 (1975). doi:10.1111/j.1744-6570.1975.tb01393.x
- Podsakoff, P.M., MacKenzie, S.B., Lee, J.-Y., Podsakoff, N.P.: Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology. 88, 879–903 (2003). doi:10.1037/0021-9010.88.5.879
- Podsakoff, P.M., MacKenzie, S.B., Podsakoff, N.P.: Sources of Method Bias in Social Science Research and Recommendations on How to Control It. Annual Review of Psychology. 63, 539–569 (2012). doi:10.1146/annurev-psych-120710-100452
- Hayes, A.: Introduction to Mediation, Moderation, and Conditional Process Analysis, Second Edition: A Regression-Based Approach (Methodology in the Social Sciences). The Guilford Press (2017)
- Kitchenham, B., Charters, S.: Guidelines for performing systematic literature reviews in software engineering. Tech. Rep. EBSE 2007-001, Keele University and Durham University Joint Report, 2007.

8

Kitchenham, B., Pearl Brereton, O., Budgen, D., Turner, M., Bailey, J., Linkman, S.: Systematic literature reviews in software engineering – A systematic literature review. Information and Software Technology. 51, 7–15 (2009). doi:10.1016/j.infsof.2008.09.009