Digital artifacts as 'templates' in routines replication across the intra-organizational boundary: An NK-based simulation model

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Abstract. Research on routines replication has rapidly grown in recent years. By conceiving digital artifacts as certain templates the replication strategy, this paper formalizes the complex interplay between component actions undertaken by human and material agencies based on Kauffman's NK theory, and employs an agent-based approach to model the internal dynamics and processes underlying routines replication from sites to sites within a decentralized organization. The simulation results show that: (1) when there are loose coupling relations of actions within and between the human and material agencies, the automation level of digital artifacts positively influences the behavioral synchrony but negatively affects the performances of the whole organization; and (2) striving to achieve the harmony between organizational tasks and the design of digital artifacts seems necessary for the success of the replication strategy. Consequently, this work not only theoretically contribute to a better understanding of routines replication dynamics, but also shed light on organizational design and the use of digital artifacts for routines replication practices in the upcoming digital age.

Keywords: Organizational Routines; Routines Replication; Digital Artifacts; NK Landscape; Agent-Based Modeling (ABM)

1 Introduction

Routines provide the ubiquitous means for participants to repetitively finish their organizational tasks through a stably standardized and consistent way, and they hence function as repositories of organizational memory, skills and tacit knowledge that constitute the sustained competitive advantage routines [1]. Some researchers addressed that organizations often endeavor to replicate those routines as 'best practices' throughout geographically distributed environmental settings to sustain profitability and competitive advantages [2-4]. In this sense, applying existing *successful* routines in new contexts is normally considered as an important value-creating strategy [2,3,5,6]. It is particularly the truth for retail chains and franchising organizations [7,8].

One underlying assumption of the replication strategy is that the core knowledge assets of a routine can be communicated and transferred from one unit to another, and then be reutilized into the new practices [3,9]. Existing literature claimed that *templates* (i.e., working examples) are essential for replicating routines [2,10,11]. However, researchers have primarily focused on either the transfer efficacy or tensions between copying the template exactly and adapting it; we still know little about whether and how templates actually do affect the learning process regarding the practices being transferred [3,7]. Furthermore, recent advances in digital technology offer rich grounds for studying the role of artifacts and materiality in routine performances [12]. For example, [13] and [14] explored the use of digital artifacts in reconfiguring and extending existing routines; and [15] showed that human-executed routines can be transformed into *automated* machines by using digital technology such as software robots and intelligent machines. In this context, this paper concerns the research question: what would happen when using digital artifacts as *templates* for replicating routines across the intra-organizational boundary?

In this paper, I create an NK-based landscape based on Kauffman's theory [16] to formalize the complex interplay between component actions undertaken by human and material agencies, and construct an agent-based model of the micro-dynamics and processes underlying routines replication activities. Leveraging the simulation data, I analyze and identify the impact of digital artifacts on routines replication dynamics. I believe contributions of this work are twofold: (1) it theoretically contributes to a better understanding of routines replication dynamics; and (2) it shed light on organizational design and the use of digital artifacts by managers and practitioners.

The rest of this paper is organized as follows. Section 2 briefly summarizes the literature on routines replication and the roles that digital artifacts play, providing sufficient backgrounds information for the research work. Section 3 then presents the design of the model. The subsequent section 4 shows the experimental design and simulation results. And section 5 is the conclusions.

2 Theoretical backgrounds

2.1 Routines replication

The term replication relates to an organization's attempts to reproduce the outcome of an existing activity through multiple geographically distributed locations [17,18], thus allowing the organization to reutilize knowledge which is already in use. At the heart of the replication strategy is to transfer a routine across different intra-organizational units while pursuing its similarity in significant aspects [3,10]. However, any mismatch between those newly created routines and the new contexts imposes the so-called 'replication dilemma' [2]. The fact is that, routines are always fixed in specific organizational and technological structures [19]. The contexts-dependence of routines requires that the recipient units not only (re)create the same 'best practices' from partners, but also exploit and explore to ensure the newly created routine being flexible and adaptive enough to the new place with subtle differences and multiplicity [5,6].

Various templates are often used throughout the life cycle of the replication strategy [2,7,10,11]. A *template* here is defined as a specific working example that contains some critical aspects of the routine and portrays in detail 'how the work gets done, in what sequence, and how various components and subroutines are interconnected' [11]. By explicitly codifying and representing the core knowledge assets like rules and procedures embedded in the original routines, these templates guarantee the similarity of newly created routines in significant aspects and facilitate transferring the core valuable knowledge of routines from sites to sites [10,11], helping preserve the value of replicating routines across the intra-organizational boundary.

Additionally, real routines are usually the products of interactions between human and material agencies which closely intertwin to repetitively accomplish their organizational tasks [5,20-22]. This indicates the two distinct sources of knowledge being involved when using templates to (re)create routines [7]: one is the knowledge encoded and represented in the templates themselves being duplicated from sites to sites; the other one is the knowledge of individual and organizational experiences in implementing those templates at the new sites. Nonetheless, both the two forms of knowledge accumulate simultaneously with learning and improved performances.

2.2 Digital artifacts as templates

A routine is commonly defined as some repetitive, recognizable pattern of interdependent actions carried out by multiple actors [17]. There is evidence that the materiality of artifacts as artifactual representations usually embodies a set of rules or procedures that provide guidance and control for the routines' enactment by facilitating certain courses of actions but making the others more difficult at the same time [23-25]. Current technological advances make digital artifacts such as software robots and intelligent machines become increasingly able to augment human actors and their agency, thus promising to radically reshape the enactment of routines [26], and/or even transform human-executed routines into automated machines [13,15,27]. The paper herein considers those digital artifacts that take actions to collaborate with human actors in accomplishing organizational tasks, and confirms that they can reposit organizational knowledge and skills, and serve as specific templates in implementing the replication strategy across the intra-organizational boundary, as illustrated in Fig. 1.

That is, the development of digital technology has made it possible to encode the core knowledge of routines in some distributed, network-based collections of both human and non-human actants [28,29], allowing the organization to transfer knowledge via duplicating digital artifacts and hence promise value creation across the organization. Whereas the core knowledge of routines which are replicable and worthy of replicating must be acquired by the recipient unit through learning behaviors due to its incompleteness nature [30] – i.e., the knowledge itself does not strictly determine individual choices and behaviors; rather, human actors can always operate discretion in interpreting those rules and procedures. It thus leaves freedom to adapt the newly created routines to the new similar but different environmental settings.

Two foundational learning mechanisms dominating such the adaptation process include: (1) human actors learn from digital artifacts as templates which encode and represent the valuable knowledge of the original routines; and (2) they learn from their own experiences triggered by implementing such new practices [7]. This implies that participants in the recipient unit can explore to dispose new digital artifacts and incorporate into those automated actions by imitating from the sending unit; or they exploit their experiences to change existing actions or even integrate new actions to collaborate with their smart workmates [31]. Moreover, mutual learning activities occur between an organization and its individuals [32,33]. This means that the organization can learn from its high-performance units, and it hence utilizes the organizational knowledge to coordinate the duplication between geographically distributed subordinates vis-à digital artifacts as templates.

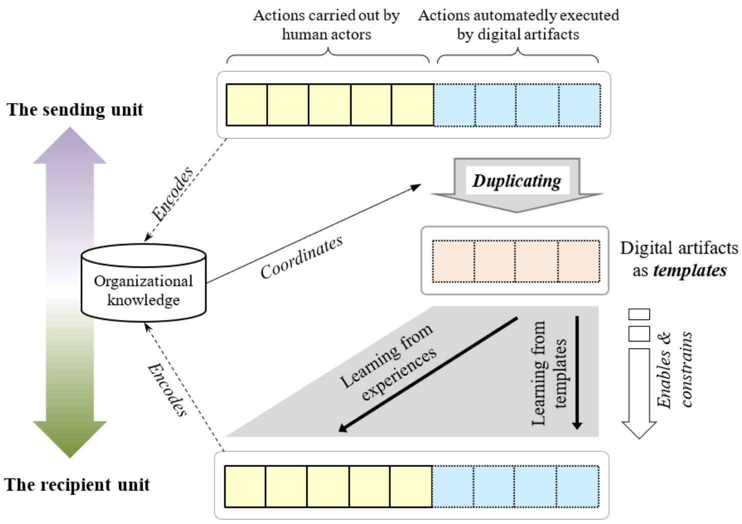


Fig. 1. Replicating routines vis-à digital artifacts as templates

3 The model

3.1 The task environment

The paper supposes that there is a decentralized organization composed of M branches which are distributed on a lattice and are randomly linked with their partners. Each branch agents consists of several human actors with a bundle of digital artifacts. Both the human and nonhuman actants intwine and they repeatedly accomplish a given organizational task. Further, the organizational task for every branch agent can be expressed as a vector of N component actions. Let N_d to denote the number of component actions being undertaken by digital artifacts ($0 \leq N_d \leq N$), and the variables $a_i^{(d)}$ and $a_j^{(h)}$ to represent component actions undertaken by material and human agencies, respectively ($0 \leq l \leq N_d$; $N_d + 1 \leq j \leq N$). When $N_d = 0$, it represents that the organizational task is completely accomplished by human actors; while at the other end of the spectrum, $N_d = N$ implies the situation that the organizational task is automatedly executed by digital artifacts. For each component action, two states being noted as 0 or 1 are randomly assigned to represent two different choices for the actants to cope with the sub-tasks they face. All the component actions make up some patterned sequences being conceived as actual performances of the routine that we concern.

I use the NKCS model [34,35] to formalize the interdependent relations between those component actions of an organizational task as that: (1) the performance of each action undertaken by human actors depends on not only this action's own state, but also the states of K ($0 \leq K \leq N - N_d - 1$) other human executed actions and C ($0 \leq C \leq N_d$) machine-automated actions; and (2) the performance of each action undertaken by digital artifacts is rigid and just determined by its own state. For every organizational task, the interdependent relations between its component actions taken by either human or non-human actants are randomly assigned [16].

However, all branch agents within the organization usually share some common goals, and they are hence 'more or less similar to each other' [36]. In this case, I follow Kauffman's NK theory [16] and use the ρMNK algorithm [37] to create M landscape matrixes with pairwise correlations $\rho = \mathbf{corr}\left[f\left(a_{i,s}, a_{i',s}\right)\right]$ ($a_{i,s}, a_{i',s} \in \mathbf{a}^{(h)} \cup \mathbf{a}^{(d)}$, $0 \leq s \leq N$ and $0 \leq i, i' \leq M$) representing the closeness between task environments of different branch agents. We have that $\rho \in [0, 1]$ and that the higher the ρ value is, the higher is the similarity between those niches that all branch agents live in.

Next, the performance of every branch agent is defined to equal to the average value of the performance contributions of all those component actions undertaken by human and material agencies within it, and the performance of the whole organization can be expressed as the average value of the performances of all the branch agents.

$$f_{agent_i} = \frac{1}{N}\left[\sum_{l=1}^{N_d} f\left(a_{i,l}^{(d)}\right) + \sum_{j=N_d+1}^{N} f\left(a_{i,j}^{(h)}\right)\right] \quad \text{(where, } 0 \leq i \leq M\text{)} \tag{1}$$

$$performance = \frac{1}{M}\sum_{i=1}^{M}\left(f_{agent_i}\right) = \frac{1}{M \cdot N}\sum_{i=1}^{M}\left[\sum_{l=1}^{N_d} f\left(a_{i,l}^{(d)}\right) + \sum_{j=N_d+1}^{N} f\left(a_{i,j}^{(h)}\right)\right] \tag{2}$$

3.2 Agents and activities

This model assumes all the branch agents as autonomous and heterogeneous, and they are bounded rational to pursue to optimize their performances being defined in equation (2). This implies that the branch agents have the motivation to communicate and replicate routines as 'best practices' from partners throughout the organization. Fig. 2 summarizes the flowchart of the simulation design. At each simulation tick, the organization as an aggregate would search for the branch agent with the highest performance. It then encodes this branch agent's use of digital artifacts as the global code or knowledge to coordinate the replication of subordinates. However, replication by duplicating digital artifacts as templates are often subject to either internal or external constraints. It hence involves a trade-off between exploration and exploitation in that branch agents need to decide how their limited resources are allocated [38].

Meanwhile, the branch agents repeatedly explore to dispose some new digital artifacts to replace the already existing ones with a probability p_{disp} ($0 \leq p_{disp} \leq 1$) to pursue to improve their actual performances. This can be realized through two distinct approaches – i.e., the branch agents can rationally utilize the organizational code or knowledge to duplicate the global optimal strategy, or they can communicate and *exactly* copy the digital artifacts from partners. The branch agents' possibility to change their digital artifacts based on the organizational code or knowledge is denoted as δ_{soci} ($0 \leq \delta_{soci} \leq 1$), which reflects the effectiveness of socialization [32]. Nonetheless, individuals of the recipient unit are required to learn from the knowledge in digital artifacts as templates and cooperate with those new artificial workmates.

When certain digital artifacts have been copied and disposed, individuals in the recipient unit are then triggered to learn from experiences and adjust the actual actions aiming at adapting to their own niches and improving performances – e.g., they might (re)interpret the digital artifacts to gain new understandings and knowledge. This allows the branch agents to change their existing actions or even integrate new actions into the newly created routines by exploiting their own experiences.

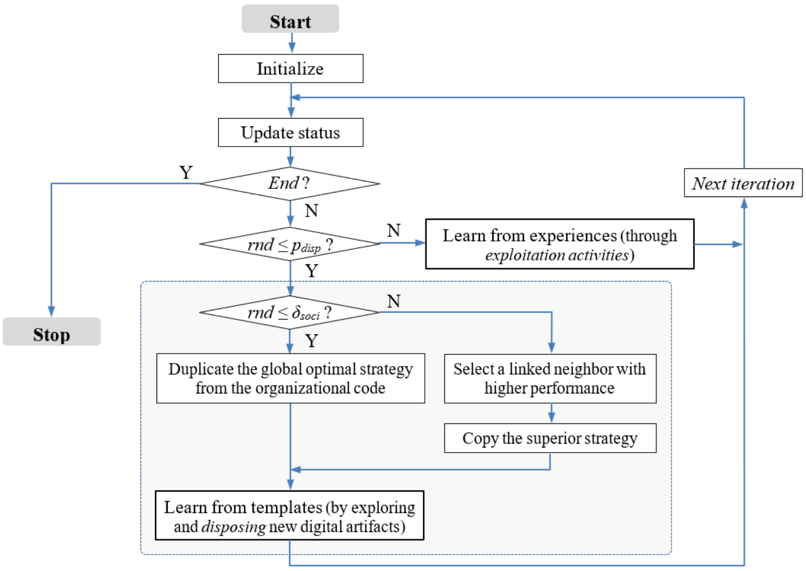


Fig. 2. The flowchart of branch agents during the simulation runs

4 Simulation design and results

4.1 Simulation design

The simulation model is constructed by using the NetLogo software (see details at: https://ccl.northwestern.edu/netlogo/). Several software engineering techniques such as structured code walkthroughs and unit testing are employed to ensure that the model is comprehensively verified. Based on a series of sensitivity analysis and robustness testing results, I run the simulation program with the following two experimental scenarios. First, I let $N_d = 2, 4, 6$ and 8 and keep the other input settings as the default values shown in **Table 1** to explore the role of digital artifacts during the organizational learning and routines replication processes (*Scenario I*). Second, I compare configurations of parameters K and C values (see in Table 2) to identify the impact of the characteristic of organizational tasks (*Scenario II*).

Table 1. Input settings of the simulation model

The parameter	Value(s) *	Description
M	16	Number of branch agents involved in the organization.
N	10	Number of component actions for the organizational task.
N_d	[2, 4, 6, 8]	Number of component actions undertaken by digital artifacts ($0 \le N_d \le N$); in contrast, the value of $N - N_d$ denotes the proportion of component actions undertaken by human actors.
K	[1, 3, 5]	Connections between component actions by human actors ($0 \le K \le N - N_d - 1$).
C	[1, 3, 5]	Connections between component actions by human actors and that by digital artifacts ($0 \le C \le N_d$).
ρ	[0.85, 0.95]	The closeness or similarity of task environments between different branch agents ($0 \le \rho \le 1$).
p_{disp}	[0.01]	Probability for branch agents to explore and dispose some new digital artifacts to replace their existing ones ($0 \le p_{disp} \le 1$).
δ_{soci}	0.1	Probability for branch agents to utilize the organizational code or knowledge to duplicate the global optimal strategy ($0 \le \delta_{soc} \le 1$); otherwise, they communicate and *exactly* copy artificial artifacts from partners with the probability $1 - \delta_{soc}$.

* **Note:** the underlined values represent the default settings of input parameters.

Table 2. Configurations of K and C values as input settings of Scenario II

$N_d = 2$		$N_d = 4$		$N_d = 6$		$N_d = 8$	
K	C	K	C	K	C	K	C
1	1	1	1	1	1	1	1
3		3	3	3	3		3
5		5			5		5

Two aggregate measures are used in the model to evaluate the simulation outputs. The first measure refers to the organizational performance as defined in equation (2). This serves as an important indicator of the outcome of branch agents by undertaking the action sequences repetitively. The second measure refers to the synchrony level, or similarity of action sequences between different branch agents. For any two branch agents i and j ($1 \le i, j \le M$ and $i \ne j$), at each simulation tick, the pairwise cosine similarity of their action sequences can be defined as

$$synlevel_{(i,j)} = \frac{a_{i,n}^{(\pi)} a_{j,n}^{(\pi)}}{\left\| a_{i,n}^{(\pi)} \right\| \times \left\| a_{j,n}^{(\pi)} \right\|} = \frac{\sum_{n=1}^{N} \left(a_{i,n}^{(\pi)} \cdot a_{j,n}^{(\pi)} \right)}{\sqrt{\sum_{n=1}^{N} \left(a_{i,n}^{(\pi)} \right)^2} \cdot \sqrt{\sum_{n=1}^{N} \left(a_{j,n}^{(\pi)} \right)^2}} \quad \text{(where } \pi = h, d\text{)} \tag{3}$$

Next, the average of all the pairwise similarity values between branch agents are utilized to represent the behavioral synchrony of the whole organization,

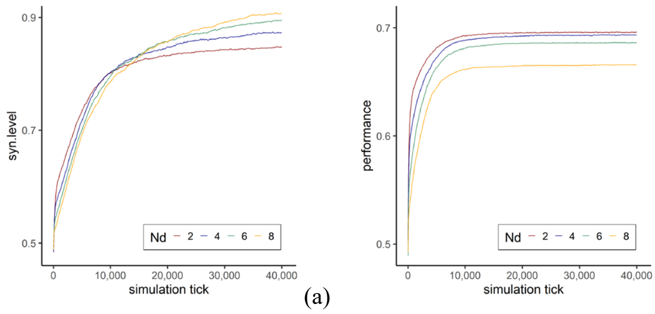
$$synlevel = 2 \cdot \sum_{i=1}^{M-1} \sum_{j=i+1}^{M} \left(synlevel_{(i,j)} \right) \Big/ M \cdot (M-1) \tag{4}$$

4.2 Simulation results

For each simulation scenario as aforementioned, I set the number of simulation runs as 300 by using the ANOVA test technique to prevent under-/over- powering of the simulation results. I keep every simulation run lasts 40000 simulation ticks that is sufficient for the routines system to converge into a stable status, and calculate mean output values for each input parameters configuration over all simulation runs.

The simulation results of *Scenario I* as shown in Fig. 3 reveal that, when there are loose coupling relations of actions within and between the human and material agencies (e.g., $K = C = 1$), it is hard for the newly disposed digital artifacts to trigger the exploitation and experiences-based learning activities in the recipient unit. In this case, if much more human-executed actions are transformed into automated machines (i.e., N_d values vary from 2 to 8), the rigidity of those digital artifacts would constrain the participants' search spaces and delimit their autonomy in decision-making. This largely restricts the variety of strategic solutions during the organizational learning, leading to a high behavioral synchrony level between branch agents (see in Fig. 3a) but suboptimal performances of the whole organization (see in Fig. 3b).

Furthermore, it was proved that although the high technological distance between branch agents increases the novelty and value of knowledge being exchanged across the organization, it preclude the mutual understanding required to utilize the valuable knowledge embodied in the newly copied digital artifacts as templates [39,40]. This elaborates not only the postponement of the organizational learning process (see in Fig. 3a), but also the decrease of organizational performances (see in Fig. 3b).



(a) (b)

Fig. 3. Simulation outputs of *Scenario I*
(a) the behavioral synchrony level; (b) the organizational performance

Next, simulation results of *Scenario II* as shown in Fig. 4 demonstrate that increasing the stickiness between human-executed actions (e.g., K values vary from 1 to 5) makes it difficult for participants in the recipient unit to progressively exploit and adjust their actions to collaborate with the newly disposed digital artifacts. Such a resistance to change individual actions, to some extent, negatively influences both the behavioral synchrony level and organizational performances. Whilst increasing the stickiness of actions between human and material agencies (e.g., C values vary from 1 to 5) has no significant effects on the behavioral synchrony level as the simulation output (see in Fig. 4a). But there exists certain intermediate C value which can yield optimal performances for the whole organization (see in Fig. 4b). The reasons might be that: very loose coupling relations between actions of both human and material agencies make it hard for participants in the recipient unit to switch to the exploitation and experiences-based learning activities triggered by the newly disposed digital artifacts as templates; in contrast, too tight coupling action relations also impede participants from improving their performances *step-by-step* through exploitative and experiences-based learning activities [4,41]. It hence confirms that pursuing to substitute machines for human beings is not always an ideal strategy for organizational operations. Hence, a trade-off should be made regarding the complex interplay between human and material agencies in the organization design practices.

Additionally, curves in Fig. 4 imply that the impact of parameter N_d values patterns similarly with several configurations of K and C values – which to some degree also verifies the robustness of the simulation outputs against different input settings. However, an exception is $K = 3$ and $C = 1$ (see in Fig. 4b) – when the routines system behaves much more complicated and further detailed discussions are needed.

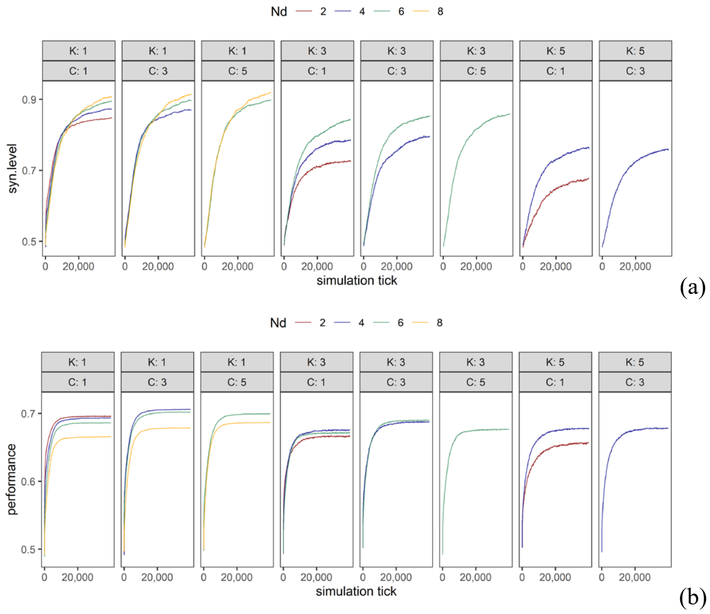


Fig. 4. Simulation outputs of *Scenario II*
(a) the behavioral synchrony level; (b) the organizational performance

5 Conclusions

In this paper, I consider digital artifacts as certain templates in routines replication across the intra-organizational boundary. I formalized the complex interplay of component actions undertaken by human and material agencies based on Kauffman's NK theory [16], and employ an agent-based approach to model the micro-dynamics and processes underpinning routines replication practices. The conclusions are that: (1) when there are loose coupling relations of actions within and between the human and material agencies, improving the automation level of digital artifacts would enlarge the technological distance between the sending and recipient units. It hence leads to obstacles for the mutual understanding necessary for participants to absorb and utilize the valuable knowledge embodied in the newly disposed digital artifacts as templates of 'best practices' [39,40]. This implies that much more attention should be paid to the actual disposition of newly developed digital artifacts which have taken on agency, rather than just fulfil a supporting function, in routines replication dynamics [15,31]. And (2) there are prevalent interrelations between the component complexity and near-decomposability of organizational tasks on the one hand, and the design of digital artifacts on the other. Such intertwining relations request practitioners to consider the decomposing characteristic of their organizational tasks when incorporating the material agency in replicating routines [42]. The paper proves that there exists some optimum configurations of the parameter K, C and N_d values which can lead to the *best* organizational performances. It's hence worthy to pursue the harmony between organizational tasks and the design of digital artifacts to provide guidelines for routines replication practices in the upcoming digital age.

Some rigid limitations of this research are that: first, either the simulation model or the analyzing results are theoretically driven, requiring empirically grounded verification and validation to capture the natural world of organizational routines [43]; second, the model considers only those digital artifacts that can reposit organizational knowledge and skills, and taking actions to collaborate with human actors; and third, some influential factors like the human-machine trust [44,45] can be involved and deeply investigated when extending this simulation model in the future work.

Acknowledgement

This research has been supported by Shandong Provincial Natural Science Foundation (No. ZR2020MG023) and College Youths' Innovative Science & Technology Program of Shandong Province (No. 2020RWG007). The authors also would like to thank the two anonymous reviewers for their constructive comments.

References

1. Nelson, R. R., Winter, S. J. An Evolutionary Theory of Economic Change. Cambridge, MA: Harvard University Press (1982).
2. Winter, S. G., Szulanski, G. Replication as strategy. Organization Science, 12(6), 730-743 (2001).
3. Friesl, M., Larty, J. Replication of routines in organizations: Existing literature and new perspectives. International Journal of Management Reviews, 15(1), 106-122 (2013).
4. Gao, D., Squazzoni, F., Deng, X. The intertwining impact of intra-organizational and routine networks on routine replication dynamics: An agent-based model. Complexity, vol.2018, doi: https://doi.org/10.1155/2018/8496235 (2018).
5. D'Adderio, L. The replication dilemma unravelled: How organizations enact multiple goals in routine transfer. Organization Science, 25(5), 1325-1350 (2014).
6. D'Adderio, L., Pollock, N. Making routines the same: Crafting similarity and singularity in routines transfer. Research Policy, 49(8), 104029 (2020).
7. Lawrence, M. Replication using templates: Does the unit learn from itself, the template, or both? Strategic Management Journal, 41(11), 1955-1982 (2020).

8. Maalouf, J. T., Combs, J., Gillis, W. E., Perryman, A. Replicate or adapt? Franchising and organizational routines. Journal of Knowledge Management, 24(4), 775-798 (2020).
9. Szulanski, G. The process of knowledge transfer: A diachronic analysis of stickiness. Organizational Behavior and Human Decision Processes, 82(1), 9-27 (2000).
10. Szulanski, G., Jensen, R. J. Overcoming stickiness: An empirical investigation of the role of the template in the replication of organizational routines. Managerial and Decision Economics, 25(6-7), 347-363 (2004).
11. Jensen, R. J., Szulanski, G. Template use and the effectiveness of knowledge transfer. Management Science, 53(11), 1716-1730 (2007).
12. Feldman, M. S., D' Adderio, L., Jarzabkowski, P., Dittrich, K. Introduction: Routine Dynamics in Action. In: Feldman, M. S., D' Adderio, L., Jarzabkowski, P., Dittrich, K. (eds.), Routine Dynamics in Action: Replication and Transformation, pp.1-10, Bingley, UK: Emerald Publishing Limited (2019).
13. Glaser, V. L., Pollock, N., D'Adderio, L. The Biography of an algorithm: Performing algorithmic technologies in organizations. Organization Theory, 2(2), 1-27 (2021).
14. Volberda, H. W., Khanagha, S., Baden-Fuller, C., Mihalache, O. R., Birkinshaw, J. Strategizing in a digital world: Overcoming cognitive barriers, reconfiguring routines and introducing new organizational forms. Long Range Planning, 54(5), 102110 (2021).
15. Rutschi, C., Dibbern, J. Towards a framework of implementing software robots: Transforming human-executed routines into machines. ACM SIGMIS Database: The DATABASE for Advances in Information Systems, 51(1), 104-128 (2020).
16. Kauffman, S. A. The Origins of Order: Self-Organization and Selection in Evolution. Oxford, UK: Oxford University Press (1993).
17. Feldman, M. S., Pentland, B. T. Reconceptualizing organizational routines as a source of flexibility and change. Administrative Science Quarterly, 48(1), 94-118 (2003).
18. Feldman, M. S., Pentland, B. T., D'Adderio, L., Lazaric, N. Beyond routines as things: Introduction to the special issue on routine dynamics. Organization Science, 27(3), 505-513 (2016).
19. Howard-Grenville, J. A. The persistence of flexible organizational routines: The role of agency and organizational context. Organization Science, 16(6), 618-636 (2005).
20. Orlikowski, W. J. Using technology and constituting structures: A practice lens for studying technology in organizations. Organization Science, 11(4), 404-428 (2000).
21. Pentland, B. T., Feldman, M. S. Designing routines: On the folly of designing artifacts, while hoping for patterns of action. Information and Organization, 18(4), 235-250 (2008).
22. Leonardi, P. M. When flexible routines meet flexible technologies: Affordance, constraint, and the imbrication of human and material agencies. MIS Quarterly, 35(1), 147-168 (2011).
23. D'Adderio, L. The performativity of routines: Theorising the influence of artefacts and distributed agencies on routines dynamics. Research Policy, 37(5), 769-789 (2008).
24. D'Adderio, L. Artifacts at the centre of routines: Performing the material turn in routines theory. Journal of Institutional Economics, 7(2), 197-230 (2011).
25. Cacciatori, E. Resolving conflict in problem-solving: Systems of artefacts in the development of new routines. Journal of Management Studies, 49(8), 1559-1585 (2012).
26. D'Adderio, L. Materiality and routine dynamics. In: Feldman, M. S., Pentland, B. T., D'Adderio, L., Dittric, K., Rerup, C., Seidl, D. (eds.), Cambridge Handbook of Routine Dynamics, pp.85-99, Cambridge, UK: Cambridge University Press (2021).
27. Sturm, T., Gerlach, J., Pumplun, L., Mesbah, N., Peters, F., Tauchert, C., Nan, N., Buxmann, P. Coordinating human and machine learning for effective organization learning. Management Information Systems Quarterly, 45(3), 1581-1602 (2021).

28. Pentland, B. T., Feldman, M. S., Becker, M. C., Liu, P. Dynamics of organizational routines: A generative model. Journal of Management Studies, 49(8), 1484-1508 (2012).
29. Gao, D., Squazzoni, F., Deng, X. The role of cognitive artifacts in organizational routine dynamics: An agent-based model. Computational and Mathematical Organization Theory, 24(4), 473-499 (2018).
30. Reynaud, B. The void at the heart of rules: Routines in the context of rule-following. The case of the Paris Metro Workshop. Industrial and Corporate Change, 14(5), 847-871 (2005).
31. Bucher, S., Langley, A. The interplay of reflective and experimental spaces in interrupting and reorienting routine dynamics. Organization Science, 27(3), 594-613 (2016).
32. March, J. G. Exploration and exploitation in organizational learning. Organization Science, 2(1), 71-87 (1991).
33. Kane, G. C., Alavi, M. Information technology and organizational learning: An investigation of exploration and exploitation processes. Organization Science, 18(5), 796-812 (2007).
34. Kauffman, S. A., Johnsen, S. Coevolution to the edge of chaos: Coupled fitness landscapes, poised states, and coevolutionary avalanches. Journal of Theoretical Biology, 149(4), 467-505 (1991).
35. Levitan, B., Lobo, J., Schuler, R., Kauffman, S. Evolution of organizational performance and stability in a stochastic environment. Computational & Mathematical Organization Theory, 8(4), 281-313 (2002).
36. Civettini, N. Similarity and group performance. Social Psychology Quarterly, 70(3), 262-271 (2007).
37. Verel, S., Liefooghe, A., Jourdan, L., Dhaenens, C. On the structure of multiobjective combinatorial search space: MNK-landscapes with correlated objectives. European Journal of Operational Research, 227(2), 331-342 (2013).
38. Lin, Z., Yang, H., Demirkan, I. The performance consequences of ambidexterity in strategic alliance formations: Empirical investigation and computational theorizing. Management Science, 53(10), 1645-1658 (2007).
39. Gilsing, V., Nooteboom, B., Vanhaverbeke, W., Duysters, G., van den Oord, A. Network embeddedness and the exploration of novel technologies: Technological distance, betweenness centrality and density. Research Policy, 37(10), 1717-1731 (2008).
40. Enkel, E., Groemminger, A., Heil, S. Managing technological distance in internal and external collaborations: Absorptive capacity routines and social integration for innovation. The Journal of Technology Transfer, 43(5), 1257-1290 (2018).
41. Lazer, D., Friedman, A. The network structure of exploration and exploitation. Administrative Science Quarterly, 52(4), 667-694 (2007).
42. Gupta, A., Hoopes, D. G., Knott, A. M. Redesigning routines for replication. Strategic Management Journal, 36(6), 851-871 (2015).
43. Gao, D., Akbaritabar, A. Using agent-based modeling in routine dynamics research: A quantitative and content analysis of literature. Review of Managerial Science, 16(2), 521-550 (2022).
44. Glikson, E., Woolley, A. W. Human trust in artificial intelligence: Review of empirical research. Academy of Management Annals, 14(2), 627-660 (2020).
45. Lee, J., Yamani, Y., Long, S. K., Unverricht, J., Itoh, M. Revisiting human-machine trust: A replication study of Muir and Moray (1996) using a simulated pasteurizer plant task. Ergonomics, 64(9), 1132-1145 (2021).