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Adaptive Workflow Design Based on Blockchain

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Abstract. Increasingly, organizational processes have become more complex. There is a need for the design of workflows to focus on how organizations adapt to emergent processes while balancing the need for decentralization and centralization goal. The advancement in new technologies especially blockchain provides organizations with the opportunity to achieve the goal. Using blockchain technology (i.e. smart contract and blocks of specified consensus for deferred action), we leverage the theory of deferred action and a coordination framework to conceptually design a workflow management system that addresses organizational emergence (e-WfMS). Our artifact helps managers to predict and store the impact of deferred actions. We evaluated the effectiveness of our system against a complex adaptive system for utility assessment.

Keywords: Workflow, Emergent Organization, Coordination, Blockchain, Smart Contract.

1 Introduction

Recurrently, large multi-unit organizations face the need for effective design of work processes that leverage contemporary technological advancements, such as blockchain technologies, to achieve efficiency goals. Relatedly, these multi-unit organizations are faced with the need to balance demands for centralized technology systems while improving the flexibility in usage at localized levels in maximizing cost and service efficiencies, and process effectiveness [1].

Consequently, organizations design and leverage automated yet adaptable workflow management systems (WfMS) to achieve these aims. Effective workflow processes ensure that an organization continues to control aspects of the work process that need direct decisions and allow for discretion in the processes that require crea-

tivity and indirect decisions. Key issues for specifying and modeling workflows "relate to task definition, task coordination and correctness of execution requirements" [2 p.3]. Workflow models or systems thus represents embedded systems of the organizing logic of the organization. Hence, their design is critical to the strategic goals of the organization. In this study, the concept of workflows is referred to as a composite set of tasks comprised of coordinated computer-based and human activities [3]. A workflow model is defined as an illustrative schema or a formal computer representation of work procedures that controls the sequence of performed tasks.

A "new logic of organizing" embraces organizations as an emergent phenomenon and affords "managerial rationale for designing and evolving specific organizational arrangements in response to an enterprise's environmental and strategic imperatives" [4]. Within the context of this logic of organizing, this study argues that, since organizational processes have become more integrative and complex, there is the need to design workflow models that incorporate organizational emergent process that are often blurred and irreducible. Emergence requires adaptation, resulting in 'complex adaptive systems' [32]. The study, therefore, seeks to design workflows principled on this new organizing logic through the development and use of theoretically driven effective and adaptive workflow systems that address emergent dispositions of contemporary multi-unit organization. The nature of blockchain technology allows for decentralization with its distributed ledger but also automation of activities to satisfy centralization goals. We discuss its tenets and its role in designing emergent organizational WfMS (e-WfMS) in later sections.

In practice, several WfMSs in use purport to offer the needed adaptivity and flexibility while meeting centralized goals via automation. Prior studies have advanced the need for the adaptive workflow to address issues with rigid automated workflows. However, these studies are grounded on proprietary conceptualized frameworks and largely lack formal theoretical support necessary to explain complex phenomena [5]. Such formal theories are the kernel theories required to advance design-related explanatory and prescriptive theory [6, 7]. Our e-WfMS design approach for a multi-unit an organization leverages the theory of deferred action (TDA) that provides a framework for addressing adaptivity and emergence in organizational work systems and processes. Based on TDA, we design a model that views workflow systems as deferred models of reality where a purposive workflow design structure is imposed on reality (current real systems) but actors are allowed to shape the design in the context of real situations in anticipation of achieving a future state [8]. In this study, we focus on adoption of an in-house (localized) smart contract, a blockchain technology, in ensuring adherence to legal dictates of the business environment and the specification of details of deferred action after consensus is reached between approving agents after negotiations in the coordination. A coded block of deferred action enables system actions that address mandatory emergent demands (such as automatic creation of future roles, processes and triggers with effective timestamps and triggers).

The specificity of our design – how it departs from prior studies – is three folds. First, the information system addressed in this study is more specific – the design of a WfMS for a multi-unit organization. Secondly, our agent-based modeling is theoretically backed. Thirdly, we leverage blockchain technologies with regards to

smart contracts with storage of consensus built in the coordination processes as deferred actions. The last, which is the major premise of our study, relates to the underlying assertion of Patel et al.'s [9] work that emergence cannot be predicted. Whiles we agree to this generality of emergence conception, it is practically the attempt to address this "wicked problem" [6] that calls for intuitive design approach. By this, the study does not claim to predict emergence exclusively, but the approach used allows for attempted prediction based on a theoretically-backed coding process that captures emergence in the short term and long term for organizational managers to make informed decisions. Our research objective thus seeks to address this problem by not only dealing with contingency factors but explaining how an e-WfMS can be effectively designed. An e-WfMS that addresses organizational emergence as a concept of coordination logic for building simulated predictions of short-term and long-term emergence. We model this as vector error correction (VEC) model of co-integrated parameters. Succinctly the research question we seek to answer is *how short-term coordination efforts affect long-term coordination efforts in informing the design of emergent multi-unit organization emergence for WfMS?*

The rest of the paper is organized as follows. The next section discusses workflows and associated management issues. Generally, the design methodology follows [10] work. We explore organizational design literature and organizational adaptation to provide the organizational principles required for our design as well as the main kernel theory used. Based on the theory of deferred action, we combine the underlying assumptions from the proffered justificatory knowledge to extract explanatory and theoretical design constructs necessary for the conceptual design and construction of our artifact. Based on the design principles, we posit two propositions necessarily to address the relevance of our conceptual design. Further, evaluation approach and discussion sections are provided. Next, we discuss implications to theory and practice. We conclude by identifying limitations to our study and areas for future research.

2 Research Background

2.1 Adaptive Workflow Systems

Alter [11] argues that the core of the information systems field should not necessarily be "IT artifact" but "IT-enabled work systems." (WfMSs embody work systems that support business processes by coordinating activities within the business processes [12]. These assertions underscore the relevance of IT-mediated workflow studies. Workflows can be referred to as a composite set of tasks comprised of coordinated computer-based and human activities [3], and a workflow model is an illustrative schema or a formal computer representation of work procedures that controls the sequence of performed tasks. Largely the need for control has informed specifications of workflows schema where the structure is rigid and characteristic of with several pitfalls such inability of users to make discretionary error identification for timely fixes.

Current technological advancements and the need for greater flexibility, organizational creativity and learning in system development implies that workflows systems

must be adaptive to improve productivity [13]. Several studies have advanced the need for the adaptive workflow to address issues with rigid automated workflows. However, these studies are grounded on proprietary conceptualized frameworks and largely lack formal theoretical support necessary to explain complex phenomena [5]. Such formal theories are the kernel theories required to advance design-related explanatory and prescriptive theory [6, 7]. The prevailing workflow systems in practice exemplify this disposition. These systems either provide smart user interfaces or flexible definitions of BPMN (business process model and notations) and DMN (decision models and notation) specifications with the view of aiding adaptivity. Mostly these are virtualization tools with less analytical capabilities buttressing the lack of theoretical backing in their design [14].

In their argument for the need for a new organizing logic in contemporary organizational design, Sambamurthy and Zmud [4] argued that even effective organizational systems are inadequate to shape appropriate insights for current business practices. They argue that the epitome of this new logic is a design that deals effectively with the emerging processes. Thus, the workflow system must do more than just having adaptive tendencies. The capability to organize IT-related activities that address this logic is seen the integrating structures available. The problem is pronounced when these integrating structures generate emergent processes that require further new adaptive processes. Although numerous adaptive systems have been fashioned to allow requisite integrating structures, lack of theoretical grounding and the rigidity imposed on the business process representation and enactment limits these systems [15]. What is needed in workflow modeling, aside the incorporation of an emergent process, is a “theoretical framework for the representation, analysis, and manipulation of workflow systems” [12 p. 9]. This study aims at deriving a set of design principles for adaptive workflow processes that are based on formal kernel theory and addresses the emergent demands of current organizational designs. The design approach, therefore, leverages the theory of deferred action that provides a framework for addressing adaptive and emergence concepts in the design of information systems [8]. The next sub-section discusses the role of blockchain as an emerging technology that emerging multi-unit organization could leverage in managing their workflows.

2.2 Blockchain Technology

Businesses have several examples of networks of individuals and organizations that collaborate to create value and wealth through the exchange of assets – information resources, goods and services – along these networks [16]. In multi-unit organizations, the coordination of activities and the consensus that is built around these coordinated activities are vital in the growth of the organization. Adaptive systems, however, due to the flexibility and adaptivity of WfMSs, actors’ (agents’) motives in negotiations and decision-making may be disparate and their activities may be clandestine. In high discretionary business environments before business processes are institutionalized, these may thwart automation (or centralization) goals. Thus, there is a need for integrity and auditability in the adaptation of work processes. It is also

important that this integrity of the system be agreed upon by relevant agents in the processes.

Blockchain technology provides the basis for a dynamic shared ledger that can efficiently and effectively expedite transactional activities among parties in the business networks [16]. Blockchain technology is a distributed ledger [17] which serves as an integrable and immutable datastore that can aid alignment of business processes and actors' activities and business goals [18] while removing transaction costs associated with intermediaries. Traditionally, blockchain was regarded as the technology behind cryptocurrencies (e.g. bitcoin) [19] which deals with the double spend problem in finance but now seen as a real alternative in many application areas [20] such as supply chain [21], internet of things (IoT), security and privacy [22], as well as WfMSs [18]. We focus on the innovative role of blockchain in the design of e-WfMSs for multi-unit emergent organizations. By leveraging the shared-ledger system, blockchain technology solves the pitfalls of transaction governance. Essentially blockchain encompasses four areas of design which are relevant to the e-WfMS design principles. These are: decentralization (work is done at different nodes without a need for the third party to build trust), data integrity and security (immutability in data stored), transparency and auditability (transparency in transaction and audits acceptable by all actors), and automation (balancing centralization goals with network involvement. For instance, use of smart contracts where ideals of the contracts are stored after consensus and requisite actions are triggered by the system) [18]. Blockchain implementation can either be public or private. For public, anyone can add to the chain whiles private chains call for approval by designated actors. We focus on permission blockchain technology (private implementation) because the study focuses on a design that addresses a phenomenon in business or private organizations. Specifically, the study illustrates the use of "smart contract" (a blockchain technology) using the a permissioned hyperledger platform enabled by IBM technologies. "A smart contract is a set of software-driven rules that encapsulate the terms agreed to by the parties involved" [17]. The specification of the contract details in the smart contracts will enable automated executions termed transactions without the need for human intervention or intermediaries. For a critical review of blockchain literature, see Kokina et al. [17].

3 Kernel Theories

The theory of deferred action (TDA) provides us with design dimensions for designing complex adaptive systems. Its strength is in the prediction that some aspects of organization work emerge and the recognition that organizational agents will respond to emergence as deferred action [8, 9]. It addresses the focal issue of designing emergent process-aware adaptive workflows required in current design organizations that affords a process perspective of the organizing logic of digitally innovative systems. Secondly, it provides the theoretical backing needed to produce artifacts from design-relevant explanatory and prescriptive theory. The core assumption of TDA is organization, organizational data, information and knowledge as well as stable systems are all emergent temporally [23]. Thus, in designing a workflow system, although the system may be designed as stable in its current state, it would be thought

of as a deferred information system. This is Patel's [8] deferred model of reality (model ontology) dimension of TDA that reflects emergence and enables appropriate responses by actors as deferred actions while pursuing predetermined goals (current adaptive specifications).

Emergence requires present, contextual, and situational aspects and historicity to be factored into the design [9]. In our context, emergence is defined as the patterns that arise through interactions of multi-unit agents, the inter-unit interactions with WfMS and the multi-unit responses to factors that affect coordinated processes (either contingent or based on the past events). Patel et al. [9], based on TDA, used agent-based simulation to assess how agents behave in emergent organizations in the present context of planned action (the real or more observable dimension the theory). As much as TDA improved our understanding for designing emergent organizations, their work provides avenues for advancing knowledge in the design of emergent organization via workflow systems by redefining the information ontology of the emergent organization as a set of coordination activities that involves agents of multi-units of the organization.

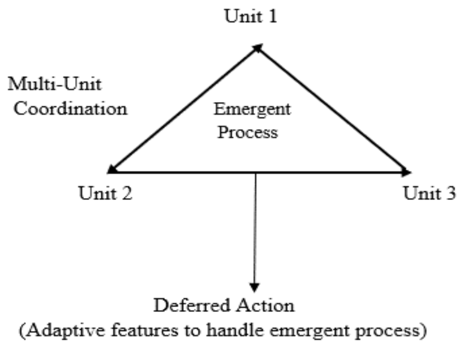

Fig. 1. Coordination in a multi-unit organization

This redefinition is in line with the criticality of identity (agents and their roles) and coordination advanced for embracing the new organizing logic [4]. Fig. 1 delineates the focus of our study and affords the use of specific kernel theories to identify agents, their roles and behavior as well as the factors that inform their actions. Consequently, the study employs Williams and Karahanna's [1] framework of coordinating processes in multi-unit organizations.

4 Design Principles on Coordination Logic

At the heart of organizational emergent processes is the view of coordination activities as a temporally unfolding process of interrelated actions [1]. This view underlines the study's conception of the new organizing logic, espoused earlier and reechoes the TDA's circumspection of temporality notion in designing emergence into systems. To this end, we focus succinctly on two coordination mechanisms critical in designing emergent workflow systems. These are generative mechanisms of consensus-making and a unit-aligning mechanism [1]. According to William and Karahanna [1], each coordinating effort is made up of structural and inner contextual design principles.

The structural principle specifies features for "operating mode" (objective, output, and accountability of coordination efforts) and "composition" (i.e., the arrangement of actors and the effectiveness of leadership and influence of managerial rationale). The inner contextual principle embraces the coordinating climate (i.e., the influence of trust and the nature of communication between organizational actors) and engagement logic (i.e., the influence of relevance, action orientation and potential organizational impact of anticipated coordination events).

Additionally, outer contexts of economic, industry/sector, legal and technological which affects the internal coordination processes are specified as design principles. This study leverages smart contracts in ensuring adherence to these outer contextual dictates of the business environment and the specification of deferred action after consensus is reached among approving agents after coordination and negotiation processes. A block of deferred action enables system actions that address mandatory emergent demands (such as automatic creation of future roles and processes based on already coded effective dates). Effective actions become adaptive actions, and because a block is a shared-ledger, activities can be assessed by all actors associated with the process including new actors enabled by the system.

5 Design Process

Design science creates and evaluates IT artifacts intended to solve identified organizational problems [24]. Our design approach follows the methodology of Peffers et al. [10]. Having motivated our research objectives, we identified the kernel theories and justificatory knowledge bases required to sufficiently address the research question. Next, we generated design principles that would enable explicit specification of the artifact in solving the identified problem. The discussion below describes the use of the iterative components of Peffers et al.'s [10] design research methodology.

5.1 Exploratory and Confirmatory Focus Group Discussion

An exploratory focus group meeting was carried out to explore these underlying assumptions of coordination for the design of emergent systems involving a three-unit organizational process — this exercise aimed at refining assumptions that followed heuristic processes of problem restructuring and artifact satisficing [25]. The coordination mechanisms were discussed, and the tentative design features and schemas for the artifact were modified after prior modeling efforts. The research question in the exploratory focus group discussion concentrated on how these coordinating mechanisms would be specified as design features for addressing emergent processes. *Based on the design principles, a confirmatory focus group discussion was used to assess the conceptual artifact design* [26]. *Feedback was used to further improve the design as shown in Fig. 2.*

5.2 Applying Design Principles

To address future impact of outer context and the other coordination elements, the study used agent-based modeling where event or happenings are specified in the

binary form of '0' and '1' based on short and long-term time goals. For instance, for an organization that recognizes the need to adopt smart contracts (blockchain technology) as part of its long-term future processes, the specification of this long-term future event is '1'. If the use of this specific aspect of the blockchain is already in place or about to be introduced, then the event is coded 0 representing short to implementation. In our context, long-term events are those of which the execution extends beyond one year (the next fiscal cycle) whereas short-term events reflect decision-making goals to be addressed within a year.

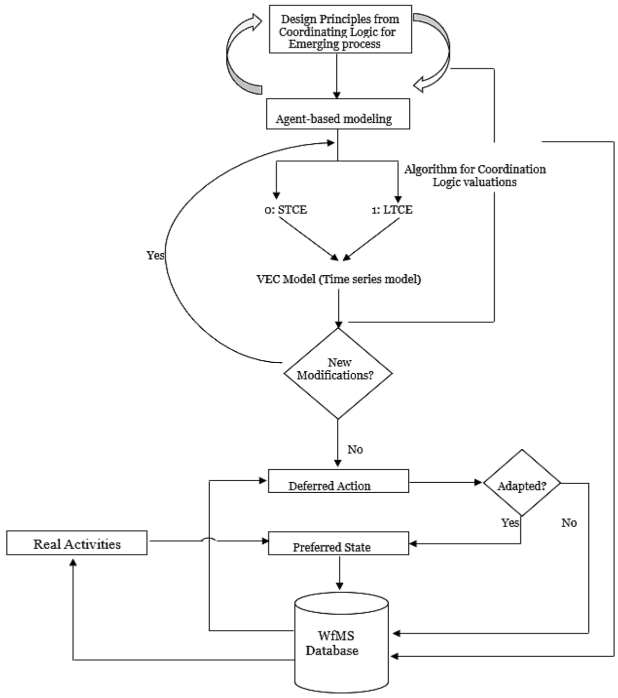

Fig. 2. Conceptual design of e-WfMS artifact

In another example, when the organization perceives that its processes may be impacted by new political and legal rules that may lead to a new emergent process in the long-term (generally more than a year), a binary '1' is specified by the system administrator based on consensus. The issue of the temporality of emergence phenomenon is addressed by allowing for changes in agent-based modeling as organizations perception of the impact of future events changes. The coordination design principles are assigned values that identify each coordination activity and the respective agents or actors. The valuation is based on the criticality of the coordinated efforts and the actors involved. The value generated is the value of the short and long-term factors for the time series. The data frequency would be daily, and the information would be stored automatically in the workflow database. The study, therefore, proposes another

artifact – an algorithm – designed for the calculation of these time series values based on defined rules and elements of the coordinated activities.

The description above allows the use of coordinating logic design principles for the agent modeling and the capture of deferred actions as though contextual factors of the coordination conception had already taken effect. For instance, in our main artifactual model, the study leverages the use of 'smart contracts' of blockchain technology as a new and representative emerging organizational design logic and an example for outer contextual factors. All the coordination principles among a three-tier multi-unit organization were specified in the algorithms for coding (programming environment). Based on the discussion we posit the following propositions:

Proposition 1*:* Short-term coordination activities will affect long-term coordination activities such that a change in the short-term consideration will impact positively impact long-term emergent efforts.

Proposition 2: The design artifact when used to analyze scenarios of coordinated activities with emergence undertones will yield significant positive results. That is, the design of WfMS that incorporates design perspectives is likely to be better positioned (more agile) compared with a system without our design perspectives.

5.3 Evaluation Approach

Our evaluation methods incorporate both experimental and analytical approaches and to some extent an observational approach [24]. The experimental procedure is the simulation processes contained in the agent-based modeling. The simulated outcomes are used as time series data for modeling the prediction of emergence. Specifically, we use the vector error correction model (i.e., cointegration vector autoregression model). This model addresses cointegration impacts and momentum effects of interacting variables (short and long-term emergence) by differencing the factors to the first-order to achieve stationarity and forecasting ability. The estimation model is then included in the coding process for our WfMS that caters for the emergent multi-unit organization. The use of case studies for evaluation is more pseudo-observational rather than observational – we use real cases to observe the behavior of our artifact, but these cases are applied as narratives rather than experiential. Finally, the advantages of this system compared to other systems would then be discussed.

The simulation approach follows, chronologically, the processes of user selection, routine and atypical composite task selection, scenario design, the design of attributes of scenario, recording data, coding textual data from the focus group, quantitative analysis of coded data and real-world testing. Thus, this simulation approach aids artifact utility evaluation via a confirmatory focus group. It would also aid to assess whether all coordinated activities necessary for the future anticipated event can be captured by the prototyped system and applied when needed. Additionally, two real business processes from prior case studies by Williams and Karahanna [1] were used as scenarios in a confirmatory focus group discussion for the evaluation. These are adapted and represents the two generative coordination mechanisms at the heart of emergent processes. The last step of the simulation approach may not be elaborate for

this study and would be realized at the modified prototypal stage of the artifact in the simulation process.

6 Conceptual Artifact Evaluation

6.1 Case Study Analysis

The organizational case to implement our conception of WfMS is adopted from William and Karahanna [1] study. The adopted case describes an IT Advisory Committee (ITAC) coordinating efforts at an organization. For a full narration of the case, see William and Karahanna [1, p. 939]. For illustrative purposes, this study focuses on how actors (agents), their roles and integrating activities generate events that inform emergence. There were 19 actors involved in the coordinating activities. We coded these actors ordinally, according to their rankings. The rank of an actor has ramifications on consensus making. Consider Table 1 for illustrative purposes.

Table 1. Agents and their ranks that define roles (Adopted from ITAC case)

Actor/Agent	Level of influence
Chief Information Officer	1
ITAC Chair and major Division IT Director	1
Public Service Sub-Committee Chair	1
Advanced Computing Sub-Committee Chair	1
Former ITAC Chair and Division IT Director	2
Division IT Director	2
Advanced Computing Sub-Committee Chair	3
IT Managerial Committee Rep	3
Central IT Budget Director	1

6.2 Algorithm for Coordination Logic Calculation (ACLC) – Algorithm 1

Each day data would be recorded based on ongoing activities and the actors involved and the consensus made. The algorithm would be iterative as events changes in a day. At the end of the business day, it records the value in the ACLC column. The smaller the calculated value the most critical the event is. After negotiation and decision making, the tentative time of implementation is set via consensus. If no consensus is reached, the situation deemed disparate but may change by the day. Each unique event is automatically assigned a primary ID. A cumulative adjustment to ACLC (CA-ACLC) would be calculated if an event changes in the days ahead and it is most likely the calculated value would be high also indicating less important activity.

Table 2 gives the parameters for ACLS calculation: fundamental ACLC formula = [(importance of event) x (sum of actors' level of influence (rank)) x (consensus level)]. So, for a moderate priority and high consensus event that requiring short term action and involving an actor ranked, one (1) and two actors ranked three (3), the

calculation for STCE, coded 0, would be 2 x 1 x (1+3+3) yielding a value of 14 which is adjusted cumulatively. The inverse values of these measures are used in the time series plot to estimate impacts of emerging events.

Table 2. Parameters and value assignment for ACLC calculation

Importance of event			Level of Influence	Consensus level		
Priority	Moder-ate	Least	Rank of exchanging actors in-volved in an event	High	Low	Dis-parate
1	2	3	1, 2, 3….	1	2	3

6.2 Vector Error Correction (VEC) Estimation of Simulated Data

Vector error correction model enables forecast of the cointegrating dynamics of the regressors (LTCE and STCE). The model can easily transition into a vector auto-regression (VAR) model to explain other dynamics of the regressors even when they are not cointegrated, hence our use of VEC. To test proposition one, the VEC model is used to plot a time series (Day against CA-ACLC) to examine the relationship between short term consensus and long-term consensus impacts. This is critical for would aid decision making as it informs the organization on what activity has the greatest impact on ongoing organizational activities. With such analytical input on emerging phenomenon, an organization would be able to estimate the time points which present bubbles or bursts for critical organizational decision making and resource allocation needs.

In Table 3, for brevity, we aggregated the consensus level and importance of event as ranked values. In practice, these represent the weighted summations of various logics that underlie unit-aligning mechanism and consensus-making mechanisms in organizational activities. The inverse of the adjusted ACLC values is used to plot the time series graph so that the greater value shows higher premium effect.

Table 3. Generating simulation data for VEC time series plot

Days	Short-term (STCE, within 3 months)	STCE ACLC	STCE CA-ACLC	Long-term (LTCE, after 3 months)	LTCE CA-ACLC	Cumulative Adjustment (CA) of ACLC
1	0 (TS1)	14	14	1		
2	…	…	15.6	….	…	…
:						

For cointegration of LTCE and STCE to exist, consider the following linear combination of two coordination effort types: $STCE_t + \beta LTCE_t = d_t$
Equilibrium in long-run emergence exists if for a given constant β, the difference, d_t is stationary. This means short run deviations away from the long-run equilibrium, $STCE_t = -\beta LTCE$ are observed when $d_t \neq 0$. Having stationarity means the short run deviations are only temporal, and if long-run equilibrium exists; $STCE_t$ and $LTCE_t$ are said to be cointegrated with vector [1, β]. The two coordination types are integrated of the order one $\boldsymbol{I}$ (1), and d_t is integrated of the order zero I (0). We tested for stationarity using GLS augmented Dickey-Fuller unit root tests [27, 28] in STATA 14. We then estimate the following:

$$\Delta STCE_t = a_S + \alpha_S(STCE_{t-1} + \beta LTCE_{t-1}) + \sum_{j}^{k} a_{SS}(j)\Delta STCE_{t-j} + \sum_{J=1}^{k} a_{SL}\Delta LTCE_{t-j} + \varepsilon_{St}$$

$$\Delta LTCE_t = a_H + \alpha_H(STCE_{t-1} + \beta LTCE_{t-1}) + \sum_{j}^{k} a_{LS}(j)\Delta STCE_{t-j} + \sum_{J=1}^{k} a_{LL}\Delta LTCE_{t-j} + \varepsilon_{Ht}$$

Where α_S and α_L speed of adjustments which explains how much of current decisions affect long-term decision. A convergence can also be estimated to explain at what point both decisions produce the same effect or value. If no cointegrating relationship exists between the two coordination efforts, both long-run and short-run speed of adjustments equal zero for the null hypotheses. The alternative is our proposition one.

6.4 Pseudo code for storing actionable consensus – Algorithm 2

```
Modification = 0//decision 0 is a no modification dummy decision based on time series output

STCE_CA-ACLC = 0

LTCE_CA-ACLC = 0

smartContract = 1

for modification = 0 to n: //agents peruse output from time series for specific cumulative STCE and LTCE's
      if decision = 1: // implies agents or actors on the network have agreed that decision outcome from
      //time series is better than previous decision
            update STCE and LCTE cumulative adjustment values, CA-ACLC
            return STCE_CA-ACLC
            return LTCE_CA-ACLC

      elif decision = 0: //implies no new decision and consensus reached
            return (store) modification = 0 on database as deferred action
            // with timestamp. Smart contract details (e.g. hiring, resource allocation, onboarding, cost
            //cutting, meeting legal requirements, etc.) are specified.
            n = 0
            store as deferred action i

      else modification = modification + 1   //this implies new modifications, for loop continues

pass

if deferred action i is triggered or acted upon

      //implies action has been adapted into organizational workflow processes and blockchain in-house
      //smart contract terminates on the specific business process negotiations. Each approved and executed
      //transaction per the smart contract is stored as transaction ids on the shared or distributed
      //hyperledger block and available to all parties.

      smartContract = smartContract + 1 //record is stored by contract number + timestamp in WfMS database

else WfMS runs in current/preferred state until later adaptation events.
```

The pseudo code to facilitate implementation of conceptual design is depicted above. For integrity and adherence to consensus decisions, a hyperledger blockchain records the actors and the actionable consensus decisions in a smart contract. This decision can only be modified after consensus by the same parties at their nodes of the blockchain. The results from the time series indicate the unique activities having the greater impact. This impact is empirically factored into the operationalization of algorithm two. Next is the assessment of organizational actors on whether they would accept system adaptation based on impact factor-related decisions. When decision is deemed better and accepted, the action is block-chained via the use of in-house multi-unit smart contract. Specific decision metrics and triggers are coded in the smart contract to facilitate realization of deferred action.

The program development is influenced by the conceptual flow shown in Fig. 2 and the discussions above. Time series estimations are interpreted and presented at each node (actors on the blockchain network) to allow for negotiation, consensus and decision making. As noted earlier, the decision mix characterizes the smart contract document for that specific coordination event on the network and in the organization at large. Modification to this contract begins from time zero. Decision reached is time stamped and parties involved are recorded. Parties by the written code can modify decision outcomes later. Future endeavors to this study should entail continual and extensive evaluation of computation cost and running time of the algorithms to optimize implementation and maximize system efficiency.

7 Discussion

We discuss the utilization of business case with respect to the link with the smart contract utilization in the conceptual design artifact and in line with our propositions. In a future prototypical assessment, proposition two can be evaluated using Patel et al.'s [9] complex adaptive system as a benchmark system to assess the effectiveness of our design artifact. Nonetheless the use of confirmatory focus group discussion helped to address key stakeholder concerns.

We utilized IBM's permissioned hyperledger fabric and hyperledger composer component (a proprietary blockchain platform for the illustration) on Blockchain Platform 2.0 to illustrate the use of smart contracts in capturing consensus. In implementing the use of smart contract, two components are key. The blockchain code and the blockchain network. The blockchain code (program script) governed transactions (i.e. the details smart contracts among the agents). This lines of coding or contractual terms are installed on the hyperledger platform as contract (s). In real organizations with coordinating teams on business events, multi-units could be several and agents each unit may have no or more than one actor participating in the business event. Our blockchain network was executed each unit or actor having a unique IP address and ID. Requisite actors are added by invitation and approval of existing parties. Communication among approving actors were enabled by the network channels. The discussion is what facilitates the complete execution of algorithm two (2) and depicts the key role of blockchain technology in this research. In the business environment, several smart contracts entailing multiple decision points can be executed depending on the business events at play in the organization. It is within this context that the impact of proposition one is addressed. The reason being that the chain of activities and consequent extent of utilization is underpinned by the agent-based modeling and the interpretations of the estimations from the VEC model. Based on the decision outcomes in a business case, the conceptual model as well as the generative algorithm used in designing the prototype system can be modified offers and this modification has implications for the contract details and defered actions.

Having assessed systems from HP, IBM and other research prototypes, Adams et al [29] outlined six key functionality criteria for commercial adaptive workflow system conceptualization and implementation. These are; flexibility and use, adaptation via reflection, dynamic evolution of work practices, locality of change and comprehensibility of process models and the elevation of exceptions to "first-class citizens". A critical review of this literature shows that our conceptualization affords these six functionality criteria.

8 Implications for Theory and Practice

This design study contributes to the theory of designed action by exploring how emergence could be designed. We also advance Patel et al.'s [9] study with the use of theory to model agents and their coordinated activities. Our approach encompasses contingency factors, the roles of the agents (included in the algorithm for calculation)

and the past histories of organizational activities. It shows how stakeholders can be used to design e-WfMS and provide recommendations for organizational managers. The nature of ACLC algorithm which encompasses individual level as well as group level parameters points to the macro-micro-macro multilevel theorization of organizational coordinating efforts that define future organizational emergence [1]. Thus, managers making decision based on the VEC forecasting model can have a better assurance of the impact at different levels in the organization.

9 Conclusion

The study derives design principles from the theory of deferred action and the coordination framework to model an e-WfMS artifact. Such an emergent system allows for the use of smart contracts in recording consensus from the coordinating activities that organizational agents engage in for the realization of key strategic goals of an emergent organization.

The study is limited by the omission of granular representations of workflow schema in the conceptual design. Granularity in the representation is not the focus of this study but future studies can explore our design of organizational emergence with such granularity to allow for clearer implementation. Narenda's [30] insightful study on flexible workflow and multi-agent interactions provides a critical bridge for such granularity in the e-WfMS design approach. The level of analysis is in this study is inter-unit. The study can be extended by examining different unit of analysis. The study can be used to design intra-unit or group emergent processes in the organization in which the impact of external units could be treated as an environmental or contextual factor. Finally in contexts such health care sector where coordination activities are central to the quality of care [31] and decision outcomes could be fatal, conceptualization of emergent workflow system would be vital in optimizing quality outcomes.

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