



**HAL**  
open science

# A Conceptual Framework of Human-System Interaction Under Uncertainty-Based on Shadow System Perspective

Qingyu Liang, Juanqiong Gou

► **To cite this version:**

Qingyu Liang, Juanqiong Gou. A Conceptual Framework of Human-System Interaction Under Uncertainty-Based on Shadow System Perspective. 12th Doctoral Conference on Computing, Electrical and Industrial Systems (DoCEIS), Jul 2021, Costa de Caparica, Portugal. pp.151-160, 10.1007/978-3-030-78288-7\_15. hal-03685920

**HAL Id: hal-03685920**

<https://inria.hal.science/hal-03685920v1>

Submitted on 2 Jun 2022

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

# A Conceptual Framework of Human-System Interaction under Uncertainty-Based on Shadow System Perspective

Qingyu Liang (✉), Juanqiong Gou

School of Economic and Management,  
Beijing Jiaotong University, Beijing, China  
{qingyu.liang, jqgou}@bjtu.edu.cn

**Abstract.** Instability is the norm, and emergency management has gradually become the norm of organizations. Due to the enterprise's business systems are developed to handle certain business under a planned and controlled assumption, cannot solve the uncertainty business. Instead, a large number of uncertain business mainly rely on people's interactives which bring diverse perspectives and sharing knowledge to solve. This paper interprets the representation of shadow system under uncertainty and further analyzes one type of obstacle of human-system interaction based on empirical analysis. Finally, this paper designs a conceptual framework about the feedback and enabling between shadow system and legal system to solve this obstacle.

**Keywords:** uncertainty · business system · shadow system · human-system interaction · conceptual framework

## 1 Introduction

Instability is the norm, and VUCA (volatility, Uncertainty, Complexity, Ambiguity) has gradually become synonymous with today's world. VUCA has been variously used to describe an environment that defies confident diagnosis and befuddles executives [1]. VUCA brings challenges to many areas of management, including design innovation, organizational structure, strategic planning, ecosystem, talent management, partnership and so on [2]. Though the words of VUCA do have related meanings, it is the differences among them that are most valuable for researchers [1]. This paper just focuses on uncertainty which is the research background and basic assumption of our research.

Taylor's scientific management theory emphasizes that the best scientific management should be based on clearly defined laws, regulations, and principles [3]. Many theories and solutions are proposed under a certain environment which means that the organization's management and business under a planned and controlled situation. Similarly, the process of IS development (ISD) is also needed to be rationally planned and controlled which is the most basic assumption [4]. The

information systems are developed for the purpose of improving the operational performance of organizations but also used to fix employees' operation process, to ensure that the business can be controllable, predictable, and planned. So, the traditional organization and business management, as well as the ISD, are all based on a certain and controllable situation.

The operation of the largest and most successful business organizations in the world is supported by ERP (Enterprise resource planning) systems [5][6]. ERP systems are the main information system in organizations. As the name of ERP contains the word planning, it's been developed under a planned and controlled situation leading to its hard to solve the uncertainty. However, when uncertainty occurs, it mainly needs robust communication and teamwork of people that bring together diverse perspectives, teams and organizations can respond adequately to uncertainty [7]. So, the information system is useless when facing uncertainty, instead, a large amount of uncertainty mainly depends on interaction and collaboration between people to handle.

This phenomenon that the people don't use the formal modes of the organization which called legal system (i.e., a pattern of common recognition among members of an organization) to handle the business of the organization, but use other inform ways which organization did not make any provision and acknowledge to handle business, is called Shadow systems [8]. In today's digital age, legal systems are mainly reflected in various business systems in enterprises, carried the fixed business process and organization's policies. But the form of the shadow system has not yet been recognized by everyone. Some scholars use a new term "shadow-IT" [9] to explain this phenomenon that the business departments and users independently implement their solutions outside of the organization's IT service [9] (e.g., Excel, database, cloud services, mobile devices and so on).

However, the authors think that Shadow IT is just a representation from the perspective of IT governance. The social activities like robust communication and teamwork of people to solve the uncertainty business which enterprise's business system cannot are the representation of shadow system under uncertainty. So, this paper wants to explain under the uncertainty assumption, what are the obstacles of human-system interaction? what is the appearance of the shadow system brought by these obstacles? And how do we use this type of shadow system? Specifically, we seek to address the following research questions:

***(1) What is the representation of shadow system brought by human-system interaction's obstacles under uncertainty?***

***(2) How to design the ideal framework of the human-system interaction under uncertainty to solve the obstacles?***

In addressing these research questions, the aim of our study is twofold. First, we interpret the representation of the shadow system under uncertainty, enrich the connotation of the shadow system. Secondly, in addition to academic significance, our research also aims to provide a way to solve the obstacles of human-system interaction under uncertainty.

The paper is organized as follows. The first section has established our motivation and the research questions. In the second section, we introduce the relationship

between our research and this conference's theme "Artificial Intelligence Application". In the third section, we review the relevant literature about our research perspective about shadow system, and emphasis the research significance. The fourth section analyzes the shadow system under uncertainty. The fifth section of this paper presents the obstacles of human-system interaction. The sixth section, the authors design the feedback and enabling cycle between the shadow system and the legal system under a idealized state. The seventh section is conclusion and research challenge. And the last section is the future work.

## 2 Relation to Applying AI

AI refers to a machine that imitates human intelligence, including perception, reasoning, learning, interaction, etc. [10], which can be broadly defined as an intelligent system with the ability to think and learn [11]. The development of AI technology has brought opportunities for enterprises to handle VUCA. For example, the decision-making process is characterized by uncertainty, complexity, and ambiguity [12]. The big data processing and analysis capabilities of AI can expand human cognition when dealing with complexity, and AI's anomaly detection and sentiment analysis capabilities can help humans deal with uncertainties and ambiguities. [13].

Meanwhile, the growing consensus that human intelligence and artificial intelligence are complementary has led to Human-AI hybrid systems, which emphasizes that when we focus on the ability of AI, we cannot ignore the importance of human's wisdom. This paper regards the social discussion of employees when facing uncertainty as one type of shadow system. So, the social data is also one representation of the shadow system, to which we need to pay attention. However, these social data contain a lot of human's wisdom, experience or others, needing us to mine them by AI technology.

The authors think that when we discuss the application of AI, we need to first determine an application scenario and a specific problem in this scenario. Secondly, we must not ignore human beings, because the current application of AI must be based on Human-AI hybrid systems [14]. Third, we need to conduct a "idealized design"[15], meaning not to focus on near-term obstacles but to think big without feeling constrained by the status quo [16].

Following these three steps mentioned above, firstly this paper focus on the shadow system problem generated by human-system interaction under uncertainty. Secondly, social data as one type representation of the shadow system under uncertainty, which contains human's wisdom needs to be mined by AI. Finally, we design the feedback and enabling cycle between the shadow system and the legal system under the ideal state.

### 3 Literature Review

Shadow system is a phenomenon, which means that the people don't use the formal modes to handle the business, but use other informed ways which organization did not make any provision and acknowledge to handle business [8]. The formal model called legal system means it gets common recognition among members of an organization [8]. The shadow system is generated after the legal system set up. Because legal systems are not 100% perfect, the organization need to fill gaps in formal structures to cope with tasks or to substitute neglected formal structures [17]. Therefore, when discussing shadow systems, legal systems must be considered.

In the current published literature, the current definition of the shadow system has not yet been unified by scholars. Some scholars think many terms that have similar meanings to the shadow system, like shadow IT, feral systems, workarounds system etc. Among them, the most popular term at present is shadow IT, which refer to the "information technology (IT) for business processes is not only provided by the IT department of the organization. Business departments and users independently implement their solutions outside of the organization's IT service management." [9].

The phenomenon of the shadow system needs to be paid attention to by scholars and business managers. Because the shadow system has many benefits and many threats. The benefits of the shadow system to the organization mainly around the creativity, innovation, and stability and order brought by the shadow system [18]. Because the shadow system can help to overcome the shortcomings of the legal system [18] and improve the organization's innovation ability and the speed of change. [17] At the same time, the shadow system can help practitioners and researchers improve enterprise systems [19]. However, the shadow system also has a lot of threats. For example, the existence of the shadow system weakens the enterprise's IT governance [20], maybe even overthrew the legal system [21]. The shadow system is also thought to violate the compliance rules [21], increasing security risks [22]and so on.

The concept of the shadow system was first proposed in the field of organization management [8]. Due to its covert characteristics, it is not easy to be discovered and managed by managers. So, with the development of information technology, all sorts of IT products used by people let shadow system can be seen in a digital way. So, the authors think shadow IT is just a digital representation of the shadow system.

As we can see, the existing literature mainly focuses on the shadow system from the perspective of IT or IS, which regard shadow system as an information system. So, there are many words with the same meaning, like feral systems, workarounds system. However, the authors think the shadow system represents one organization's phenomenon from the perspective of management science. So, the representation of the shadow system is diverse, and we need to enrich the connotation of the shadow system.

### 4 Shadow System under Uncertainty

Under the current uncertain environment, represented by abnormal business, cross-boundary business, innovation business, and emergent businesses, becoming the main part of the organization's daily business. Due to the enterprise's business systems are developed to handle certain business under a planned and controlled situation, leading to its hard to solve the uncertainty business. Therefore, a large number of uncertain business mainly rely on people to solve.

About causes of uncertainty, there are two reasons. One is due to lacking knowledge [23], the other is due to the complexity of the system [23][4]. So, when facing uncertainty, people need to collaborate, with robust communication and teamwork that bring together diverse perspectives [7] and sharing knowledge to identify and handle uncertainty [2]. Therefore, the author thinks that the shadow system of the organization under uncertainty is caused by the flexibility of the business system not well when facing the uncertain business. And the main form is the people's interaction and discussion comes same or different organizations, according to an offline virtual team, online social software discussion, etc.

As shown in the Fig.1 below, facing the uncertainty, business systems are becoming less and less valuable, and people are getting busier and busier. The shadow system used as the main way for business departments to quickly develop solutions to meet emergency needs.

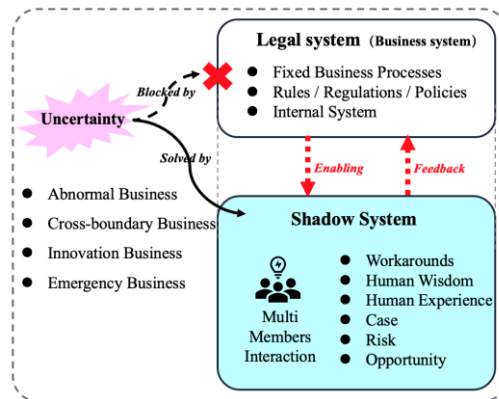


Fig. 1. The relationship between uncertainty and shadow system.

According to Clark [24], “much of what matters about human intelligence is hidden not in the brain, nor in the technology, but in the complex and iterated interactions and collaborations between the two”. So, the shadow system is a treasure for the organization. As shown in Fig.1 above, a large number of workarounds, human wisdom, human experience, case, risk and opportunity will be retained in the shadow system after the uncertain events are solved by people. So, the authors think the enterprise need to make use of the treasure in the shadow system and improve the flexibility of the business system under uncertainty, which is the feedback of the shadow system and enabling of the legal system shown as a red arrow in the figure.

The authors think that the social data which generated by handling the uncertainty business which enterprise's business system (legal system) cannot handle is one representation of the shadow system under uncertainty. In order to specifically understand the current interaction between the employees and the business system under uncertainty, we conducted an empirical qualitative study, which will be discussed in the next section.

## 5 Human-system Interaction Obstacle

This section mainly analyzes the obstacles between the employees and the business system in the enterprise, through interviews with a company's employees and Beijing Jiaotong University's MBA students. And the authors divide three states of human-system interaction, as shown in Fig.2 below.

In the past state, the development of business system mainly comes from the "best practice" of staff's daily work. Due to these businesses can be planned and controlled, we call them general business, which the business system developed for handing them efficiently. The authors think the general businesses represents certainty which enterprise's information system can play its biggest value.

About the obstacles in human-computer interaction at present, we interviewed a company manager and conducted in-depth discussions with MBA students in the form of a focus group. We have compiled the following two representative interview data from numerous interview data. The manager of the enterprise we interviewed said:

*"Our company has 12 people in total, but we have specially arranged a colleague to enter data into our BCP system (The business system of the interviewer's company) regularly, because the headquarters will review our work through this system. This system has become a burden on our work, rather than helping us."*

Similarly, a MBA students said:

*"WeChat and QQ (Both Chinese social APP) has become my main way to handle my daily work in my company. Many uncertain events require me to discuss with different apartments' colleagues or call other company employees by different social apps."*

As we can see that in the current uncertainty state, a large number of uncertain businesses are mainly solved by people in the enterprise, while business systems are becoming more and more useless. However, in order to manage and control the enterprise, after uncertain businesses have been solved by people, it also needs human to input business data into the business system, to ensure the business systems can record the real business, which increases the workload of human. According to our data analysis of interviews with MBA students and one enterprise employees, we find a large number of Chinese enterprises are in this stage now. As mentioned above, due to IS development (ISD) is under a planned and controlled assumption, causing some Chinese enterprises are now in this obstacle situation.

In order to solve this problem, our "idealized design" is aim to extract the

knowledge, which contains workarounds, people wisdom and experience of shadow system as mentioned in part 4. By embedding these shadow system’s knowledge into the business system, to improve the flexibility and intelligence of the business system, so as to better-enabling frontline employees. The specific idealized design content will be introduced in detail in the next section.

## 6 Feedback and Empowerment

Based on the analysis of obstacles in the human-system interaction in part 5, this part aims to propose a conceptual framework of feedback and empowerment between shadow system and legal system, As shown in Fig.3 below.

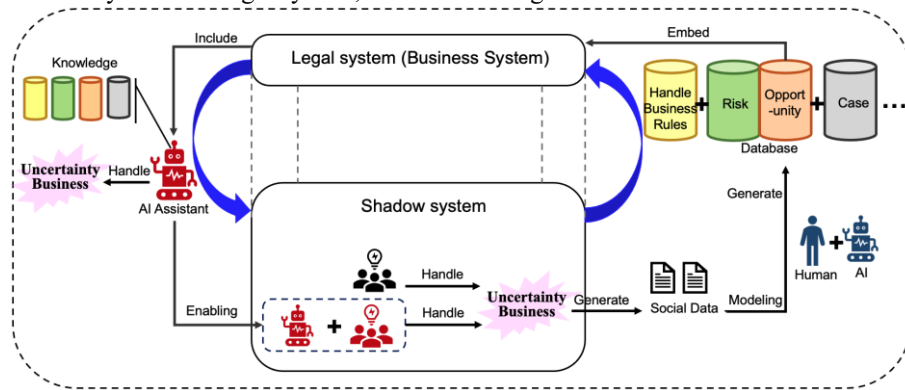


Fig. 2. Feedback and enabling cycle of shadow system and legal system.

According to the introduction of shadow system under uncertainty in part 4 above, and empirical analysis in part 5, we can see that human’s social data among people can be regarded as one representation of shadow system. However, the authors emphasize again that social data refers to the interactive data that employees aim to handle uncertain businesses that enterprise’s business system (legal system) cannot handle.

We analyze the social data with purpose, mainly hope to extract relevant social data (contains human wisdom, human experience, risk and opportunity etc.), building risk and opportunity base, case base, and business rules for handling uncertain events, and embed this knowledge bases into the business system. Many organizations are looking to expand the capabilities of their systems by integrating new modules, or addons, into their core business system implementations [25]. We embed human intelligence in the business system with the mode of the database, which is suit for the current information system development line.

After completing the feedback from the shadow system to the legal system, we also need to pay attention to the enabling of the business system to frontline employees. In the process of enabling frontline employees, we focus on human-AI collaboration. AI assistant contains much of the knowledge base, which comes from the human. And they can handle some uncertain businesses by themselves to a certain extent. At the same time, it can assist people to solve some uncertainty.



## 7 Conclusion and Research Challenge

This paper firstly introduces the relationship between uncertainty and the shadow system in the organization, and we particularly emphasize that under the current uncertain assumption, the phenomenon of shadow systems will become more and more popular, and it needs attention from scholars and enterprise managers. Meanwhile, we discussed the content that may exist in the shadow system.

Then the authors analyzed a type of obstacles in human-system interaction based on interviews with MBA students and one company's manager. Based on this obstacle, we design a framework about feedback and enabling between the shadow system and the legal system under an idealized state. Under this framework, we regard the social activities of employees when facing uncertainty as one type of shadow system.

Although the authors' conceptual framework is designed under the idealized state, we still need to pay attention and try to solve the obstacles in the process. In our research, we mainly face two obstacles as follow.

- The degree of CEO attention. When we introduced the importance of social data to some CEOs through the concept of shadow systems, we found that some CEOs attach great importance to them and have developed timely social functions in the business system. However, because they do not know how to use social data, they have not forced employees to have to use it. And some CEOs believe that social data is not very useful, and believe that employees only need to follow business standards and complete business through legal systems to achieve their goals (Fig.3, Current state). Many authors have emphasized that business leaders should play the main role and lead the enterprise to control VUCA [2][16]. Therefore, the obstacles of CEO's understanding and acceptance of the shadow system need to be further studied.
- Social data privacy issues. Currently, WeChat (one most widely used social APP in China.), as a public social software for the masses, has unclear boundaries between public and private data. At the same time, many people believe that social data is their privacy and are unwilling to share it. Therefore, when this research was first carried out, we asked MBA students to see their own social data the discussion about business, and let them voluntarily share it in class. The major of MBA students thought that interactive data contain a lot of knowledge that can be used in the future.

## 8 Future Work

In the current research, the data we mainly analyze comes from WeChat APP. We let MBA students voluntarily contribute social data about the discussion about uncertainty in their daily work.

However, to solve the two research challenges mentioned above, the next phase work of our research is to develop the virtual simulation platform for a certain case enterprise to come true to our ideal design of feedback and empowerment between

shadow system and legal system. There are two main reasons for us to develop virtual simulation:

- The real information system of enterprise is complexity, it cannot be easily tested and implement our design. It is difficult for business leaders to promote innovation and change when they do not see actual results. So, through the development of a virtual simulation platform, the real information system and real business can be simulated to a certain extent, which is convenient for us to conduct experiment. Meanwhile, the virtual simulation platform allows the CEO to visually see our experiment results.
- Due to the privacy of social data and the inseparability of data related to private life and business discussions, it is difficult to collect useful data. By designing communication function in the virtual simulation platform, when multiple people are playing games together, facing the uncertainty needs to make decisions, players from different departments can establish discussion groups, and social data will be collected by platform.

**Acknowledgments.** Funding for this research was provided by the National Natural Science Foundation of China (61972029).

## References

1. Bennett, N & Lemoine, G.J.: What a difference a word makes: Understanding threats to performance in a VUCA world. *Bus Horizons*. 57,311–317(2014)
2. Millar, C. C. J. M., Groth, O., & Mahon, J. F.: Management innovation in a VUCA world: challenges and recommendations. *Calif Manage Rev* (2018)
3. Taylor, F. W. *The Principle of Scientific Management*. New York: Harper Brothers (1911)
4. Benbya, H., Nan, N., Tanriverdi, H., Yoo, Y.: Complexity and Information Systems Research in the Emerging Digital World. *MIS Quart* 44(1), 1-17 (2020).
5. Liang, H., Saraf, N., Hu, Q., Xue, Y.: Assimilation of Enterprise Systems: The Effect of Institutional Pressures and the Mediating Role of Top Management. *MIS Quart*.31(1) 59-87 (2007)
6. Morris, M. G., Venkatesh, V.: Job Characteristics and Job Satisfaction: Understanding the Role of Enterprise Resource Planning System Implementation. *MIS Quart*.34(1)143-161 (2010)
7. Baran, B.E & Woznyj, H. M. *Managing VUCA: The human dynamics of agility*. *Organ Dyn* (2020) ‘
8. Stacey, R. *Complexity and creativity in organizations*. BerrettKoehler, SanFrancisco, CA (1996)
9. Zimmermann, S., Rentrop, C., & Felden, C.: Managing shadow IT instances—a method to control autonomous IT solutions in the business departments. In: *Twentieth Americas Conference on Information Systems*, Savannah (2014)
10. Rai, A., Constantinides, P., and Sarker, S. Editor’s Comments: Next-Generation Digital Platforms: Toward Human–AI Hybrids. *Mis Quart* 2019,43(1), iii-ix(2019)
11. Russell, S., & Norvig, P.: *Artificial intelligence: a modern approach*(3rd ed.). Pearson(2015)
12. Choo, C. W.: Towards an information model of organizations. *The Cana J Infor Sci*, 16(3), 32—62(1991)

13. Jarrahi, & Hossein, M.: Artificial Intelligence and the Future of Work: Human-AI Symbiosis in Organizational Decision Making. *Bus Horizons*. 61(4), 577-586(2018)
14. Aleksander, I. :Partners of humans: a realistic assessment of the role of robots in the foreseeable future. *J Inf Technol*. 32(1),1-9(2017)
15. Ackoff, R.L., Magidson, J., Addison, H.: *Idealized Design* .FT Press(2006.)
16. Schoemaker, P. J. H. , Sohvi, H. , & David, T.: Innovation, dynamic capabilities, and leadership. *Calif Manage Rev*(2018)
17. Behrens, S., and Sedera, W.: Why Do Shadow Systems Exist after an ERP Implementation? Lessons from a Case Study. In: *The 8th Pacific Asia Conference on Information Systems*, Shanghai, China.1712-1726(2004)
18. Behrens, S.: Shadow systems: the good, the bad and the ugly. *Commun ACM*(2009)
19. Jones, D., Behrens, S., Jamieson, K., Tansley, E.: *The Rise and Fall of a Shadow System: Lessons for Enterprise System Implementation*. ACIS (2004)
20. Huber, M., Zimmermann, S., Rentrop, C , et al. The Influence of Shadow IT Systems on Enterprise Architecture Management Concerns, In: *European, Mediterranean and Middle Eastern Conference on Information Systems*. Springer, Cham(2017)
21. Panko RR.: Spreadsheets and Sarbanes-Oxley: regulations, risks, and control frameworks. *Commun Assoc Inf Syst*.17,647–676 (2006)
22. Silic M, Back.: A Shadow IT – a view from behind the curtain. *Comput Secur*. 45,274–283(2014)
23. Brugnach, M. Pahl-Wostl, C., Lindenschmidt, K. E., Janssen, J., Gaber, N.N.: Complexity and uncertainty: rethinking the modelling activity. *Dev Integr Environ Asses*, 3(08), 49-68(2008)
24. Clark,A.*Mindware: An Introduction to the Philosophy of Cognitive Science*. New York: Oxford University Press(2001)
25. Beatty, R. C. , & Williams, C. D. ERP ii: best practices for successfully implementing an ERP upgrade. *Commun ACM*.49(3),105-109(2006)