

PAPER • OPEN ACCESS

Influence of Product Modularity on Performance of Old Buildings' Promotion and Transformation Projects

To cite this article: Yayun Cao and Weiyi He 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **267** 032037

View the [article online](#) for updates and enhancements.

Influence of Product Modularity on Performance of Old Buildings' Promotion and Transformation Projects

Yayun Cao^{1, a}, Weiyi He^{2, b}

¹School of Management, Tianjin University of Technology, Tianjin 300384, China;

²School of Management, Tianjin University of Technology, Tianjin 300384, China.

^a15822266963@163.com, ^bweiyihe5@126.com

Abstract: Old buildings' function promotion and transformation in cities is a new way to effectively improve people's livelihood and vigorously stimulate domestic demand. However, government, as the sponsor of old buildings' promotion and transformation projects, experiences a policy dilemma that exactly how to respond to the masses' individual demands rapidly while taking the efficiency of supply into account. This article focuses on that if the modularity theory, which is applicable to private sector, can solve dis-economies of scale caused by customized supply in public sector. Through a case study in Tianjin, we find functional module partition mode and structural module partition mode, the main considerations of modular design, can make an influence on decision flexibility, whose intention is function configuration; and then, decision flexibility influence project performance by allocating optional space and speed.

1. Introduction

The renovation project of the old residential quarters of urban residents, including the green renovation, can meet the growing needs of the people for a better life, solve the imbalance in the allocation of municipal services resources, and quickly produce the effect of social mobilization. However, a large number of old residential areas have the characteristics of non-private property, requiring government-led project organizations established by various departments to deliver a large number of renovation engineering products with different contents within the stipulated time limit and annual public expenditure budget, while taking into account the green elements such as energy conservation and renovation. How to quickly respond to the individualized demands of the old residential quarters, while taking into account the transformation of the scale economy of product supply, has become a new challenge that needs to be innovated through project management. The success of modularization in the private sector makes it possible for the public sector to adopt modularized means to solve similar contradictions encountered in the supply of livelihood products. However, researchers have not yet paid attention to how modularity plays the same or different management role and significance in the public sector as in the private sector. This research adopts exploratory case study method and takes the old building district comprehensive function upgrading and renovation project in Tianjin downtown as the case study object. It deconstructs the renovation task and process from the perspective of modular design, with a view to exploring the internal modular mechanism in the management efforts to achieve the renovation project performance. A large number of problems in district renovation projects provide countermeasures.



2. Literature Review

Physical components of modular product system are divided into modules. Modular functions and their physical components are one-to-one mapping relationship under a specific requirement^[1]. With the change of business environment, the object of modularization gradually extends to process, organization and service. Therefore, it can be considered that the object of modularization includes at least products, processes, organizations and services^[2,3]. At present, modularization researches mainly focus on the application and expansion of modularization in enterprises^[4-7]. Few studies have focused on how to apply modularization in public projects to solve large-scale supply and efficiency problems of engineering products with customization characteristics.

In the study of flexibility, the most widely cited is the flexibility of production system proposed by Mandelbaum, which refers to the rapid response ability of production system to environmental changes or uncertainties caused by environmental changes^[8]. Kangkang Yu believes that operational flexibility is an ability to deal with uncertainties, whether active or passive, and can be divided into two dimensions: manufacturing flexibility and supply chain flexibility. The flexible manufacturing mainly comes from the inherent uncertainty and output variability, supply chain flexibility comes mainly from marketing, products, competition, demand and production etc^[9]. Therefore, among the many effects caused by modular design, project decision flexibility may be the intermediary link between modular design and project performance.

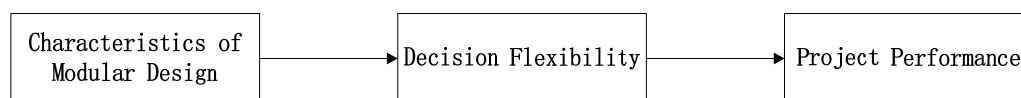


Figure 1 Benchmark theory model of modularization mechanism for old residential district renovation project

3. Research Design

The research problem of this paper is to find out the clues and rules of modularization in old residential reconstruction projects. It is necessary to combine the specific project practice situation and through systematic observation and reflection to find out the relationship between modularization and performance improvement of old residential reconstruction projects. Therefore, exploratory case study method is applicable.

Following the criterion of "theoretical sampling" in case selection^[10]. In order to ensure the traceability of the case, this study selected the comprehensive function upgrading and reconstruction project of the old building area in the central city of Tianjin. In order to ensure the reliability and validity of the study, this study followed the "triangular validation" criterion in data sources, and tracked data for four consecutive years from 2012. In vertical case studies, stage division is a priority^[11]. The first step is to sort out the collected data along the time dimension. The second step is to analyze and summarize the state changes of project decision flexibility and project performance. The third step is to explore the significant correlation between the characteristics of product modular design and the flexible state of project decision-making and the state of project performance, so as to establish the relationship among them.

4. Research Findings

Figure 2 shows the concept of eventual emergence and its interrelationship. The results show that these two concepts not only exist in the decision-making process of the case project, but also many engineering products delivered by the renovation project are based on a small area (building area) as a product quantity. We have made a comprehensive and systematic state combination of functional module partition dimension and structural module partition dimension, called module partition mode, and found that some of these modes exist in the case. The event context of the case shows that it is the different module partitioning modes that affect the flexibility of decision-making of the transformation

project; thus, the flexibility of decision-making has an impact on the performance of the transformation project. The performance of the renovation project is reflected in three dimensions, namely, the quantity and scale of products completed in unit time, the total progress of the project and the overall effect of the project.

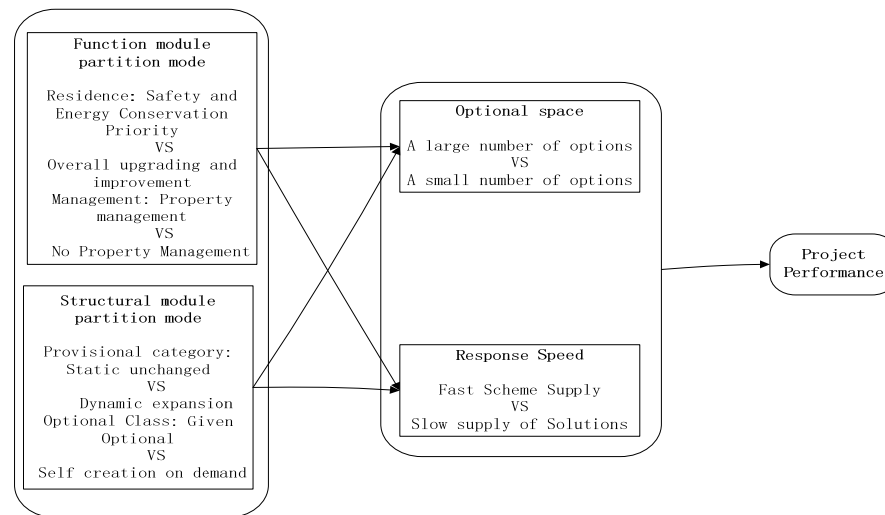


Figure 2 Summary of case results of modular design features, flexibility and project performance of old building renovation projects

4.1. The relationship between modular design features and project decision flexibility

4.1.1. Function Module Partition Model and Project Decision Flexibility

The model presented in the first year of reform is "safety and energy saving first + no property management". This mode objectively leads to the project decision-making marked by the functional scheme design of each district in the whole city, which belongs to the low-grade basic livelihood allocation and meets the basic living needs of the masses. In 2013, the mode changed to "Safety and Energy Saving First + Property Management". Property houses appeared, but the incremental module still focused on public safety and energy saving. In 2014, the mode was renewed to the mode of "comprehensive improvement and upgrading + property management". The number of functional module libraries continued to expand and entered a new state. Strengthen the functions of community security monitoring and control, which objectively increases the level of functional module configuration, and can flexibly respond to the needs of the people of the new residential areas for security, green environment, convenience and other different living levels. To sum up, we propose proposition 1:

The partition mode of functional modules of transformed products affects the flexibility of project decision-making for transformed product supply.

4.1.2 Structural Module Partition Patterns and Decision Flexibility

From the mode reflected in the implementation plan of the reconstruction project of old buildings in Tianjin, the division of structural modules in the first year of reconstruction is in the mode of "dynamic expansion + given optional" and in a low distribution state to meet the basic livelihood of the people. Under the condition of low allocation, the adjustment ability of project decision-making is weak. Obviously, the rigidity of decision-making is more than enough and the flexibility is insufficient. The structure module division in 2013 and 2014 is in the mode of "dynamic expansion + on-demand self-creation". Under this mode, self-creation on demand makes every district appear self-creation

function module every year, which is more close to the actual community and household needs with the times. By 2015, the functional design of the renovation products of each district or isolated building will be quick and accurate. To sum up, we propose proposition 2:

The partition mode of structural modules of transformed products affects the flexibility of project decision-making for transformed product supply.

4.2. Flexibility of Project Decision-making and Performance of Renovation Project

In the process of promoting the transformation project, the functional module partition mode and the structural module partition mode of the transformation product have changed dynamically in each year, and the decision flexibility of the project has also changed accordingly. Firstly, in the process of product design transformation, it is closer to the potential real functional needs of the masses and improves the flexibility of project decision-making. Secondly, by providing the required and expandable functional module space, on the premise of guaranteeing the construction quality, shorten the construction time of each district, and realize the "more", "faster" and "better" in the project performance composition. Therefore, we propose proposition 3:

The flexibility of project decision-making in transforming product supply affects the performance of transforming project.

5. Discussion and conclusion

Based on the longitudinal analysis of the case of the comprehensive function upgrading and renovation project in the old building area of Tianjin, this study finds that the modular design characteristics of project deliverables or district products are the key factors affecting the flexibility of project decision-making. When the functional module division is in the priority of safety and energy saving, and there is no real estate housing mode, the decision-making flexibility of the reconstruction project is in a weak state. When it is in a comprehensive upgrade and improvement, and has the property housing mode, the decision-making flexibility is in a strong state. When the partitioning mode of structural modules is in the dynamic expansion of the prescribed items of functional modules and the self-selection is constrained by the given optional range, the decision flexibility is in a weak state; when the prescribed items are in the dynamic expansion and the self-selection is self-created on demand, the decision flexibility is in a strong state.

References

- [1] Hao Li, Guoning Qi, Yangjian Ji. (2013) Service-Oriented Product Modular Design Method and Its Prospect. *J. China Machinery Engineering*, 24(12):1687-1695.
- [2] Hui Wang, Wenhua Hou. (2013) Research on the Impact of Business Process Modularity on Business Process Outsourcing Incentive Contract under Bilateral Moral Hazard. *J. Journal of management*, 10(2):244-251.
- [3] Shujun Yao, Juhong Chen, Yiwei Zhao. (2012) Research on the Evolution Process of Product and Service Modularization under Service-oriented Manufacturing Mode. *J. Scientific and Technological Progress and Countermeasure*, 29(9):78-83.
- [4] RAMACHANDRAN K, KRISHNAN V. (2008) Design Architecture and Introduction Timing for Rapidly Improving Industrial Products. *J. Manufacturing & Service Operations Management*, 10(1):149-171.
- [5] SMEDLUND A. (2008) Identification and Management of High Potential Professional Services. *J. Management Decision*, 46(6):864-879.
- [6] ETTLIE J E, KUBAREK M. (2008) Design Reuse in Manufacturing and Services. *J. Journal of Product Innovation Management*, 25(5):457-472.
- [7] LEHRER M A. Modularity vs. (2009) Programmability in Design of International Products: Beyond the Standardization-Adaption Tradeoff. *J. European Management Journal*, 27:281-292.
- [8] Shoufeng Zhang, Jintian Ge, Minmei Huang. (2004) Strategic Consideration on

- Constructing Flexible Supply Chain. J. Scientific and Technological Progress and Countermeasure,21(1):112-113.
- [9] YU K,CADEAUX J, LUO N. (2015) Operational Flexibility: Review and meta-analysis. J. International Journal of Production Economics,169:190-202.
- [10] EISENHARDT K M. (1991) Better Stories and Better Constructs: The Case for Rigor and Comparative Logic. J. Academy of Management Review,16(3):620-627.
- [11] Xunmin Peng, Xiaobo Wu,Dong Wu. (2011) Evolution of Balanced Model of Enterprise Network and Organizational Learning Based on Dynamic Process of Secondary Innovation—Hai Tian Longitudinal case studies from 1971 to 2010.J. Management World,4:138-149.