# The Influence of Product Architecture and Supply Chain Concentration on Supply Chain Performance

**Caili Duan, Xiaochun Chen, and Yuanxun Gu**

**Abstract** Supply chain is an important support for value creation, and product is the carrier for realizing the value. The coordination between product architecture design and supply chain management is the premise for enterprises to cope with rapid changes and meet the market demands. The view that product architecture and supply chain interact with each other has been confirmed by many scholars, but the influence mechanism between the two is still unclear. We collected data from 221 companies and drew the following conclusions through analysis. (1) product architecture has a significant impact on supply chain performance. The modularity of product architecture, the degree of standardization of interface, and the reuse of components have a significant positive impact on supply chain performance. (2) supply chain centralization can enhance the effect of product architecture on supply chain performance. When supply chain concentration is high, product architecture is easier to play its advantages, thereby improving supply chain performance.

**Keywords** Product architecture · Supply chain performance · Supply chain concentration

## 1 Introduction

With the rapid development of technology, products are in a fast cycle market, if an enterprise wants to obtain the competitive advantage, it needs not only higher product development capacity and production capacity, but also a fast and sensitive

The Fundamental Research Funds for the Central Universities (2019 YJS067).

C. Duan (✉) · X. Chen · Y. Gu
School of Economics and Management, Beijing Jiaotong University, Beijing, China
e-mail: 17113181@bjtu.edu.cn

X. Chen
e-mail: 17113179@bjtu.edu.cn

Y. Gu
e-mail: guyanxun@bjtu.edu.cn


M. Li et al. (eds.), *IEIS2019*,
https://doi.org/10.1007/978-981-15-5660-9_33

supply chain. Supply chain is an important support for value creation and value realization. Integrating product architecture design and supply chain decision- making in product development is the key to value realization. However, current research on product design and supply chain design remains in their respective fields. The decoupling of product architecture improves the flexibility of product architecture. Product architecture design is the coordination mechanism for production, process and supply chain matching. Therefore, the interaction between product architecture and supply chain has gradually attracted the attention of scholars. Summarizing the current research on the relationship between product architecture and supply chain, most scholars explained the matching relationship between product architecture and supply chain through theoretical deduction and mathematical modeling, and very few empirical studies have been conducted. Therefore, based on the existing research, this paper analyses the relationship between product architecture and supply chain performance of manufacturing enterprises, and draws the conclusion that the product architecture affects supply chain performance. The impact mechanism provides a theoretical reference for product architecture design and supply chain management.

## 2 Conceptual Framework and Research Hypothesis

### *2.1 Supply Chain*

Forrester first proposed the concept of supply chain [1], then scholars defined the concept of supply chain as an enterprise network which is made of many independently economic entities that are related to each other and work together to carry out value-added activities and dynamically configure resources. Since then, the research on supply chain management has gradually received attention. The concept of supply chain management was first proposed by Houliban in the 1980s [2]. With the deepening of scholars' research on supply chain management, the scope of supply chain management has been expanded. Cooper et al. argued that supply chain management emphasizes the transaction and cooperation among the node enterprises of supply chain [3]. Cooperating with each other improves the efficiency of supply chain which is an innovation management strategy among enterprises. Domestic scholars such as Ma tend to integrate the concept of management, he said that supply chain management implements the logistics planning and control functions in the whole process of supply chain from the initial supplier to the final consumer [4]. From the above, this paper arguments that supply chain management is a comprehensive management process in which enterprises plan, coordinate and integrate supply chain information flow, logistics and capital flow scientifically in order to respond quickly to the market.

Supply chain performance is the overall efficiency of supply chain operation, including the internal performance of the enterprise itself and the coordination and cooperation performance among the node enterprises [5]. In the existing literature, most of the research focused on the establishment of supply chain performance evaluation and index system. In recent years, scholars have found that many factors can affect supply chain performance, such as upstream and downstream partnerships in supply chains [6]. Many experts have devoted themselves to the study of new methods for evaluating supply chain performance, such as increasing order fulfillment efficiency from OFE model to SCOR model to reflect the comprehensive correlation between input and output; others have used structural equation model to analyze the relative weights of each evaluation index, identify the main factors affecting supply chain performance and summarize the sustainability. Using factor analysis method to simplify the indicators, the evaluation strategy of supply chain performance establishes a scientific and reasonable standardized evaluation index system [7]. Xiong believed that improving the participation level of suppliers is conducive to improving the operation performance of the supply chain, while increasing the participation level of customers is conducive to improving the service performance of the supply chain [8]. Liu et al. after studied the profit sharing contract in supply chain thought that profit sharing contract has an impact on supply chain performance [9]. Taking conflict management ability and cooperation stability as influencing factors, Zhou studied their influences on supply chain and concluded that both of them are beneficial to improve supply chain performance [10]. By analyzing relevant researches on supply chain performance and combining the purpose of this paper, the supply chain performance measurement scale developed by Lu and Li was adopted to measure the supply chain performance. The scale includes three dimensions: financial performance, production service performance and supplier operation performance, which includes 12 items in total [11].

In order to explore the influence of supplier relationship on the relationship between product architecture and supply chain performance, this paper chooses supply chain concentration as the moderating variable. The concentration of supply chain is composed of the concentration of suppliers upstream and downstream of the supply chain and customer concentration. Zhuang also pointed out that supply chain concentration consists of two dimensions: supplier concentration and customer concentration [12]. This model is conducive to long-term cooperation between enterprises and suppliers. Customer concentration reflects the concentration of customers, the higher the customer concentration, the fewer the number of customers [13]. Wu regarded supply chain concentration as the integration of supply chain management [14]. Other scholars have different definitions of supply chain concentration, in essence, supply chain concentration reflects the idea of integration of supply chain resources and management optimization. Therefore, this paper argues that the essence of supply chain concentration is the strengthening of strategic partnership among supply chain enterprise members and the enhancement of information sharing and process management capabilities. On this basis, this paper defines the concentration of supply chain as the close partnership among the enterprises, the upstream and downstream suppliers and customers. This paper chooses three indicators to measure the concentration of supply chain: the concentration of enterprises and upstream suppliers, which is measured by the sum of procurement ratios of the top five suppliers, and the concentration of enterprises and downstream customers, which is measured by the sum of sales ratios of the top five customers.

### 2.2 Research on Product Architecture

The term architecture comes from the discipline of systems management to simplify complex system problems. The earliest application of architecture to management was in Ulrich' research [15], who proposed the concept of product architecture and applied architecture-related theory to product development and design. Moreover, he believed that product architecture is a systemic solution that is achieved by assigning different functions of the product to different physical modules [16], embodying the decomposition and integration of product systems. Based on product characteristics, Fixson believed that the product architecture includes the type and number of modules and interfaces between two modules, which reflect the basic structure of the product [17]. And modules do not exist independently, but interact and influence, and then react and express through the interfaces [18]. Therefore, the product architecture embodies the system integrity of the product, and the interface, module and system are the three basic elements of the product architecture. The emergence of modular product architecture provides a solution for complex product design, it also reduces the difficulty of supply chain management and operation management related to complex product design, therefore it attracts the attention of academic circles.

When Baldwin and Clark studied the role of modularity, they proposed six operations to change product architecture, namely, splitting, substituting, adding, removing, creating new design rules, transplanting, and briefly described the relationship between product architecture changes and organizational changes [19]. Christensen indicated that modular architecture and integrated architecture are two extremes in spectrum. When enterprises rely on functions to gain competitive advantage, they will choose integrated architecture and modular competitive advantage when enterprises gain competitive advantage with speed [20]. Whether a product is modular or integrated can only be judged when compared with other products, so it is only a relative attribute of product architecture. It can be seen that the evolution of product architecture is not a simple choice between modularity or integration, but needs to be adjusted according to the context [21]. In this paper, Fujimoto and Takahiro's views were adopted to measure the form of the product architecture through the modularity, the degree of interface standardization and the reuse of components. The larger the value of the three dimensions, the more integrated the form of the product architecture would be.

### 2.3 Research Hypothesis and Model Construction

With the deepening of scholars' research on supply chain and product architecture, many scholars have studied the influence of product architecture on supply chain management and design. Yassine et al. believed that the modular product architecture can reduce the interaction between components and the coordination difficulty of the R&D team, ultimately reducing the R&D cost and shortening the lead time of delivery, which is conducive to improving the response capacity and efficiency of the supply chain [22]. At the same time, modularized norms and uniform language can reduce the effort of suppliers and customers, which can promote the exchange of information between the two parties, and help to improve the level of trust between the two sides, thereby reducing risk of cooperation between companies and suppliers and customers [23]. In addition, component reuse in modular products helps to reduce the investment risk of module or component manufacturers, and enables manufacturers to diversify their products at the lowest cost, thus quickly meeting different market needs. Therefore, modular product architecture enables enterprises to achieve parallel production, thereby improving the resource utilization of enterprises and shortening the lead time of product delivery. However, some scholars argued that modularization of product architecture will increase the cost of assembly and transportation, and that when an enterprise outsources modules, it will lose the knowledge of architecture and technical information related to modules in the long run.

In summary, product architecture is closely related to supply chain performance, but there is no consistent conclusion on the research of product architecture on supply chain performance, and scholars mostly use case studies and theoretical deduction to explain the relationship between product architecture and supply chain. Therefore, this paper proposes the hypothesis:

H1: The product architecture form has a significant impact on supply performance.

H1a: The modularity of product architecture has a positive impact on supply chain performance.
H1b: Component reuse has a positive impact on supply chain performance.
H1c: The standardization of interface has a positive impact on supply chain performance.

Based on transaction cost theory and resource-based theory, supply chain partners can reduce transaction costs and save transaction time through cooperative trust, thus improving the performance of core enterprises and even the whole supply chain. High-quality cooperation between enterprises and suppliers can make supply chain more competitive [24]. The high concentration of the supply chain is conducive to the good cooperation between the company and the procession, and the long-term cooperation has established a good trust among the industry, suppliers and customers, and formed a transaction specification. When Nuria et al. studied the supply chain cooperation relationship they concluded that the operational efficiency of decentralized partner enterprises lacking contract mechanism in the supply chain was difficult to improve [25]. Jiang studied the characteristics of partnership, and believed that relationship trust and institutional trust positively affect the operation performance and financial performance of supply chain [26]. Long put forward that commitment mechanism helps manufacturers to maximize benefits in multiple supplier proposals [27]. Guo et al. constructed a coordination model of competition and cooperation game of three-level supply chain [28]. It was found that with the increase of the number of suppliers and sellers, the competition between suppliers and sellers became increasingly fierce, the bargaining power of suppliers and sellers would weaken, and the bargaining position of core enterprises would rise, thus improving the supply chain performance of core enterprises. However, Behncke and others show that the higher the modularity of product architecture, the higher the demand for the relationship between supply chains [29]. Therefore, the role of product architecture is affected by the cooperation among enterprises, suppliers and customers. However, the cooperation relationship of supply chains varies greatly with the concentration of supply chains, so the impact of product architecture on supply chain performance is significant. It will be disturbed by supply chain concentration. Thus, the following assumptions are put forward:

H2: Supply chain concentration has a significant impact on supply performance.

H2a: Supplier concentration has a positive impact on supply chain performance.
H2b: Customer concentration has a positive impact on supply chain performance.

H3: Supply chain concentration plays a moderating role in the impact of product architecture on supply chain performance.

H3a: Supply chain concentration plays a moderating role in the relationship between modularity and supply chain performance.
H3b: Supply chain concentration plays a moderating role in the relationship between interface standardization and supply chain performance.
H3c: Supply chain concentration plays a moderating role in the relationship between component reuse and supply chain performance.

The theoretical model of the article is shown in Fig. 1.
The regression equation is

$$Y = \beta_0 + \beta_1 X + \beta_2 m + \varepsilon \tag{1}$$

$$Y = \beta_0 + \beta_1 X + \beta_2 m + \beta_3 X m + \varepsilon \tag{2}$$

The partial derivative of Y with respect to m is obtained:

$$\frac{\partial \hat{y}}{\partial x_1} = \beta_1 + \beta_3 x_2 \tag{3}$$

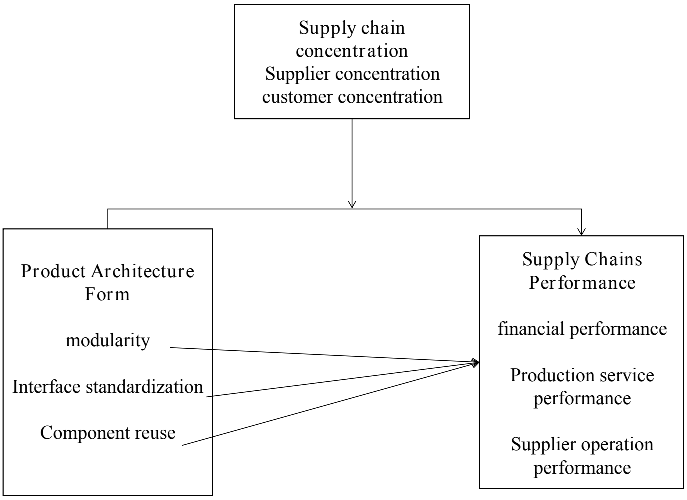


**Fig. 1** Hypothesis model

If $\beta_3$ is significant, then the adjustment variable is significant.

# 3 Research Design

We adopt the method of questionnaire survey and use SPSS19.0 statistical software to analysis the data. Before conducting the formal questionnaire survey, we first test the reliability and validity of the scale, and collect the data on the basis of ensuring the reliability and validity of the scale.

## *3.1 Data Collection*

The research focused on manufacturing enterprises in North China. In August 2018, pre-study was carried out, and 40 questionnaires were collected. According to the survey results, the measurement of each variable has good reliability and validity. On September 20, 2018, a formal data survey was conducted, and 260 manufacturers were surveyed and 221 questionnaires were returned. The validity rate of the questionnaire was 81%.

**Table 1** The results of confirmatory factor analysis

| Variable | Fitting index | | | | | |
|---|---|---|---|---|---|---|
| | $\chi^2$/df | CFI | GFI | PNFI | RMSEA | AGFI |
| PAF | 1.934 | 0.857 | 0.878 | 0.570 | 0.045 | 0.850 |
| SCP | 2.020 | 0.800 | 0.850 | 0.789 | 0.039 | 0.824 |
| SCC | 2.568 | 0.936 | 0.946 | 0.678 | 0.056 | 0.868 |

### *3.2 Construct and Measurement*

The reliability of the results is tested by the Cronbach's coefficient.

$$\alpha = \frac{\kappa}{\kappa - 1}(1 - \sum \frac{s_i^2}{s_t^2}) \tag{4}$$

$\alpha$ is the reliability coefficient, $\kappa$ is the number of questions tested, $s_{\mathrm{i}}^2$ is variance of scores for each question, $s_{\mathrm{t}}^2$ is variance of total score.

The Cronbach's coefficient of product structure form is 0.879, and the Cronbach's coefficient of supply chain performance is 0.912. The Cronbach's coefficient of supply chain concentration is 0.935. The Cronbach's coefficient of the scale used in this paper is greater than 0.80, so the scale has good reliability and can be further analyzed.

To test the validity of the scale, $\chi^2$/df, RMSEA, GFI, CFI, AGFI and PNFI are used to observe the structural validity of the scale.

$$\frac{x^2}{df} = \frac{(N - 1)F}{df} \tag{5}$$

If $\chi^2$/df < 3, then the results are valid. The results of the test are shown in the table. All the indicators in the validity test result of the scale reach the acceptable range, so the scale used in the study has good structural validity (Table 1).

### *3.3 Data Analysis and Results*

The mean, standard deviation and correlation coefficient of each variable are as follows. Table 2 shows that the correlation coefficient between variables is significant. The correlation coefficient formula is

**Table 2** Mean, standard deviation and correlation matrix of variables

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Business scale | | | | | | | |
| Industry type | −0.017 | | | | | | |
| Sales | 0.054 | 0.035 | | | | | |
| Years | 0.133* | −0.264 | 0.273 | | | | |
| PAF | −0.194 | 0.006 | 0.037 | −0.123 | | | |
| SCP | 0.029* | 0.136 | 0.253** | 0.345 | 0.468** | | |
| SCC | 0.183** | 0.022 | −0.410 | 0.129 | 0.473** | 0.480** | |
| Mean value | 3.580 | 3.770 | 2.970 | 3.400 | 4.117 | 3.834 | 3.947 |
| Standard deviation | 0.495 | 0.886 | 0.380 | 0.390 | 0.863 | 1.026 | 0.804 |

$$r = \frac{\sum_{i=1}^{n} (x_1 - \overline{x})(y_1 - \overline{y})}{\sqrt{\sum_{i=1}^{n} (x_1 - \overline{x})^2 \sum_{i=1}^{n} (y_1 - \overline{y})^2}} Z \tag{6}$$

## 3.4 Hypothesis Test

The relationship between variables and the regulatory effect of regulatory variables are tested, and the results are shown in the Table 3.

In the Table 3, $R$ represents goodness of fit. It is used to measure the goodness of fit of the estimated model to the observed values. The closer its value is to 1, the better the model will be. Adjusted $R^2$ represents the ratio of the sum of squares of regression to the sum of squares of total dispersion.

$$\text{Adjusted } R^2 = 1 - \frac{n-1}{n-p-1}(1 - R^2) \tag{7}$$

And $F$ is the significance test of regression equation, if

$$F > Fa(k, n-k-1) \tag{8}$$

Then, the explanatory variables of the model have significant effects on the explanatory variables. $n$ is sample size, $k$ is the number of independent variables.

The data of model 1 is the regression result when controlling variables are introduced. The data of model 2 introduces product architecture form on the basis of model 1. The results show that product architecture form has a significant impact on supply chain performance ($\beta = 0.136$, $p < 0.001$), and the degree of modularity has

**Table 3** The results of hierarchical regression

| Variable | Supply chains performance (SCP) | | |
|---|---|---|---|
| | Model 1 | Model 2 | Model 3 |
| Business scale | 0.078** | 0.078 | 0.096 |
| Industry type | −0.067 | 0.067 | 0.006 |
| Sales | 0.001 | 0.001 | 0.004 |
| Years of establishment | 0.028 | 0.028 | 0.065* |
| product architecture form (PAF) | | 0.136*** | 0.330** |
| Modularity (M) | | 0.230** | 0.176 |
| Interface standardization (IS) | | 0.217** | 0.220** |
| Component reuse (CR) | | 0.109* | 0.140** |
| Supply chain concentration (SCC) | | | 0.328*** |
| Supplier concentration (SC) | | | 0.279*** |
| Customer concentration (CC) | | | 0.213** |
| SCC × M | | | 0.264** |
| SCC × IS | | | 0.201 |
| SCC × CR | | | 0.215** |
| R | 0.699 | 0.731 | 0.749 |
| Adjusted $R^2$ | 0.479 | 0.517 | 0.531 |
| Value of F | 6.374* | 11.039*** | 10.521*** |

a significant impact on supply chain performance ($\beta = 0.230$, $p < 0.01$). The degree of standardization of interface has a significant impact on supply chain performance ($\beta = 0.217$, $p < 0.01$). Component reuse has a significant impact on supply chain performance ($\beta = 0.109$, $p < 0.05$). The hypotheses H1, H1a, H1b, H1c are verified.

In model 3 supply chain concentration degree is introduced on the basis of model 2. The results show that supply chain concentration degree has a significant impact on supply chain performance ($\beta = 0.328$, $p < 0.001$), supplier concentration degree has a positive impact on supply chain performance ($\beta = 0.279$, $p < 0.001$), customer concentration degree has a positive impact on supply chain performance ($\beta = 0.213$, $p < 0.01$), and supplier concentration degree has a positive impact on supply chain performance ($\beta = 0.213$, $p < 0.01$). And the impact of supplier concentration on supply chain performance is higher than the impact of customer concentration on supply chain performance. The hypothesis H2, H2a, H2b are verified. The adjustment effect of supply chain concentration is tested and the concentration of supply chain promotes the impact of modularity on supply chain performance (0.264 > 0.230). Supply chain concentration can not adjust the impact of interface standardization on supply chain performance ($p > 0.05$), but supply chain concentration promoted the impact of component reuse on supply chain performance (0.205 > 0.109). The hypothesis H3, H3a, H3c are established, H3b is not established.

The values of R in the three models are respectively 0.699, 0.731, 0.749. Adjusted $R^2$ are 0.479,0.517,0.531, and $F > Fa$ $(k, n - k - 1)$, therefore, the test results are valid.

## 4 Discussion

Based on the research of product architecture form and supply chain, this paper makes an empirical study on the relationship between product architecture and supply chain performance, and explores the impact of modularity of product architecture on supply chain performance, so as to provide theoretical basis for enterprises to choose product architecture form and improve supply chain performance.

By analyzing the survey data, this paper concludes that the form of product architecture has a significant impact on supply chain performance, and the modularity of architecture, the degree of standardization of interface and the reuse of components have a positive impact on supply chain performance, among which the degree of modularity has the largest impact on supply chain performance. Second, supply chain concentration has a significant effect on supply chain performance, as well as the reuse of components and play a regulatory role in the performance of supply chain relationship. Supply chain concentration promotes the impact of product architecture on supply chain in both paths. Therefore, product architecture with high modularity, high standardization of interface and high reuse of components has higher flexibility and responsiveness, which make enterprises can better respond to market changes, meet customer needs and improve the efficiency of supply chain.

At the same time, this study expands the theory of product architecture and verifies scholars' conjecture about the relationship between product architecture and supply chain. However, the research can be further improved, next, the authors will expand the sample and measure the variables used in the study in a more scientific way and will try to find other influencing variables to explore the relationship between product architecture and supply chain performance ulteriorly.

**Acknowledgements** Thanks to my partners for their help, thanks to the international conference team for their help, and thanks to the Fund Projects' support.

## References

1. Forrester, J. W. (1997). Industrial dynamics. *Journal of the Operational Research Society, 48*(10), 1037–1041.
2. Houliban, J. (1984). *Proceeding of the 19th international technical conference of the British production and inventory control society*. London: Supply Chain Management.
3. Lambert, D. M., Cooper, M. C., & Pagh, J. D. (1998). Supply chain management issues and research opportunities. *International Journal of Logistics Management, 9*(2), 1–20.

4. Ma, S. H., Lin, Y., & Chen, Z. (2000). *Supply chain management*. Beijing: China Machine Press.
5. Spiliotopoulou, E., & Donohue, K. (2016). Information reliability in supply chains: The Case of Multiple Retailers. *Production and Operations Management, 25*(23), 548–567.
6. L. M. Ellram (1992). Supply chain management: The industrial organization perspective. *International of Physical Distribution and Logistics Management.*
7. Firouzi, F., Jaber, M. Y., & Baglieri, E. (2016). Trust in supply forecast information sharing. *International Journal of Production Research, 54*(5), 12.
8. Xiong, W., Sun, Y. L., Li, Y., & Feng, T. W. (2014). Influence of supplier and customer participation on supply chain performance. *Industrial Engineering and Management, 19*(2), 1–8.
9. Liu, J. & Maerhua. (2004). Research on supply chain cooperation and its contract. *Journal of Management Engineering, 18*(1), 85–87.
10. Zhou, R. H. (2013). Research on the influence of knowledge sharing level and conflict management ability on supply chain performance. *Science and Technology Management research, 33*(20), 161–165.
11. Lu, S., & Li, D. (2017). Research on the relationship between organizational learning, relational capital and supply chain performance. *Journal of Central South University (Social Science Edition),* (6), 82–90 (2017).
12. Zhuang, B., Yu, S., & Zhang, H. (2015). Supply chain concentration, capital operation and operational performance: an empirical study based on Chinese manufacturing listed companies. *Soft Science, 29*(3), 9–14.
13. Patatoukas, P. N. (2012). Customer-base concentration: implications for firm performance and capital markets. *Accounting Review, 87*(2), 363–392.
14. Wu, X. J. (2007). Research on supply chain integration. *China Circulation Economy, 21*(2), 22–24.
15. Ulrich, K. (1995). The role of product architecture in the manufacturing firm. *Research Policy, 24*(3), 419–440.
16. Ulrich, K., & Eppinger, S. D. (2004). *Product design and development* (3rd ed.). New York: McGrwa-Hill.
17. Fixson, S. K. (2005). Product architecture assessment: A tool to link product, process, and supply chain design decisions. *Journal of Operations Management, 23*(3–4), 345–369.
18. Meyer, M. H., & Lopez, L. (1995). Technology strategy in a software products company. *Journal of Product Innovation Management, 12*(4), 294–306.
19. Baldwin, C. Y., & Clark, K. B. (2000). *Design rules: The power of modularity*. Cambridge: The MIT Press.
20. Christensen, C. M. (2006). The ongoing process of building a theory of disruption. *Journal of Product Innovation Management, 23*(1), 39–55.
21. Liu, H., Song, H., & Feng, Y. X. (2015). Research on the adaptive relationship between product modularity and supply chain integration. *Science of Science and Technology Management, 36*(9), 93–104.
22. Yassine, A. A., Joglekar, N. R., Braha, D., Eppinger, S. D., & Whitney, D. E. (2003). Information hiding in product development: The design churn effect. *Research in Engineering Design, 14*(3), 145–161.
23. Hoek, R. I. V., & Weken, H. A. M. (1998). How modular production can contribute to integration in inbound and outbound logistics. *International Journal of Logistics Research & Applications, 1*(1), 39–56.
24. Gao, J., & Lee, J.D. (2006). A dynamic model of inter-action between reliance on automation and cooperation in multi-operator multi-automation situations. *International Journal of Industrial Ergonomics.*
25. Nuria, M., Rodríguez, L., & Adrián, E. (2017). Coronado mondragón. exploring quality generating factors in customer-supplier relationships. *Gospodarka Surowcami, Mineralnymi, 33*(4), 157–176.

26. Jiang, C. C. (2012). Research on supply chain partnership to improve supply chain performance – the characteristic of partnership is a moderator variable. *Science and Technology Management Research, 32*(16), 236–241.
27. Long, H. Y. (2016). Research on collaborative procurement consultation and coordination of multi-agent supply chain based on commitment management mechanism. Beijing University of Technology.
28. Guo, H. L., Hou, Y. X., & Yang, B. H. (2008). Game coordination model of three-level supply chain of M suppliers, 1 manufacturer and N dealers. *China Management Science, 16*(6), 54–60.
29. Behncke, F. G. H., Walter, F. M. A., & Lindemann, U. (2014). Procedure to match the supply chain network design with a products' architecture. *Procedia Cirp, 17,* 272–277.