

# Digital supply chain construction of mahogany furniture based on the haotai forest model

Xiaofei Ma<sup>1,a</sup>, Zixin Li<sup>2,b</sup>, Jiashun Yang<sup>3,c</sup>, Xiixin Zhong<sup>2,d</sup>, Jun Ma<sup>3\*</sup>

<sup>a</sup>Xiaofeima0206@163.com; <sup>b</sup>lizixin360@126.com; <sup>c</sup>2381014889@qq.com  
<sup>d</sup>2284485433@qq.com; \*drmajun@pku.org.cn

<sup>1</sup>School of Transportation Nanning University, Nanning, Guangxi, China

<sup>2</sup>School of Innovation and Entrepreneurship Education Nanning University, Nanning, Guangxi, China

<sup>3</sup>School of Business, Nanning University, Nanning, Guangxi, China

**Abstract.** Mahogany furniture refers to the use of sour branches, rosewood and other precious hardwood furniture, this kind of furniture by virtue of expensive materials, exquisite production technology and unique design style favoured by consumers. This paper analyses the digital supply chain construction based on the Haotailin model, and concludes that the construction of a digital supply chain can help the mahogany furniture industry upstream and downstream to reduce costs and increase efficiency, and this paper also concludes that the mahogany furniture supply chain can help the mahogany furniture industry to coordinate and stabilise its development through the construction of a digital ecosystem, the use of one-stop purchasing digital cloud platform, and the integration of a large model of intelligent identification of the whole process of information, to realise the price and efficient control of the materials.

**Keywords:** Howlin' Thai Models, Mahogany Furniture, Digital supply chains, Coordination and collaboration in supply chain networks

## 1. Introduction

Mahogany furniture refers to the furniture made of mahogany material, currently occupying the market is mainly the ancient palace furniture represented by the Ming and Qing styles, its unique texture and noble and luxurious status symbols deeply respected by consumers. With the gradual expansion of mahogany furniture market scale, showing a diversified, high-end development trend. However, the rise of the younger generation of consumers and aesthetic concepts of the new generation, as well as limited by its expensive price, the market demand for larger changes, China's mahogany furniture industry supply chain rigidity and other issues. How to not affect the original quality of mahogany furniture on the basis of both improve supply chain efficiency, but also reduce the price to expand the consumer base, has become the industry's hot spot.

## **2. Mahogany furniture industry development status quo**

### **2.1 The current situation of mahogany furniture products**

Expensive mahogany furniture is usually considered a high-end luxury product, the production of which requires exquisite craftsmanship and scarce wood, and therefore higher prices, which makes mahogany furniture for some consumers may be an expensive investment[1].

### **2.2 Current status of the supply chain in the mahogany furniture industry**

Rosewood is a precious and rarer wood with a long growth cycle. There is an imbalance between supply and demand of raw material supply. Procurement is highly influenced by the local natural environment and local policies, and fluctuations in the supply of mahogany can affect the stability of the furniture production process[2]. The raw materials used in the manufacturing process of mahogany furniture rely heavily on imports, and in recent years, China's mahogany industry is facing a sharp decline in imports, mahogany prices are rising rapidly the double impact of the rising prices of materials and policy changes affecting the development of China's mahogany furniture industry, leading to the industry reshuffle phenomenon, some companies have to exit the market, how to achieve coordination and collaboration of supply chain networks is the industry's problem[3].

### **2.3 Impediments to the development of digital supply chain in the mahogany furniture industry**

Many enterprises in the mahogany furniture industry lack sufficient technical investment, resulting in the slow development of the digital supply chain, while the supply chain partners in the mahogany furniture industry include raw material suppliers, manufacturers, logistics companies, etc., which have different levels of digitisation and lack of a unified data port, requiring collaborative integration of digital platforms. However, the large amount of capital investment required for the construction of digital supply chain makes the enterprises' determination to invest insufficient, so some enterprises may still follow the traditional concept and management mode, and take a conservative attitude towards the development of digital supply chain[4].

## **3. Analysis of digital supply chain construction of mahogany furniture**

In this paper, the market demand function of product  $x$  is portrayed using the Hauterin model. Compared with other models, the Hauterin model changes the previous assumption that mahogany furniture is completely homogeneous, and introduces the differences between mahogany furniture, that is, the differences between mahogany furniture in the spatial location, which solves the "Bertrude paradox" and is closer to the real-life situation of consumers' choice of mahogany furniture[Fig. 1].

The model assumes that the raw materials of mahogany furniture are the same in material properties, and the difference in raw materials of mahogany furniture is mainly reflected in the different spatial locations of raw material suppliers; assuming a length of 1 raw material supply

area space, mahogany furniture consumers are at the ends of the interval  $[0, 1]$ , and the consumers are evenly distributed in the interval between  $[0, 1]$ ; the difference in spatial location will make the consumers incur travelling costs, and assuming that the unit travelling cost is  $t$ ; Consumers are rational consumers, so providing the lowest total cost of mahogany furniture raw material suppliers will be more attractive to consumers, satisfy  $P_1 + tx = P_2 + t(1-x)$ , can be calculated to obtain the demand function:  $Q_1 = \frac{P_2 - P_1 + t}{2t}$  with  $Q_2 = 1 - Q_1$  [5].

### 3.1. Mahogany furniture supply chain problem description and related assumptions

In this paper, it is assumed that there are two mahogany supply chains in the mahogany raw material market, and each mahogany supply chain consists of a mahogany furniture raw material supplier  $F_x$ , a mahogany furniture consumer  $S_x$ , and the corresponding consumer. The two mahogany furniture raw materials  $F_x$ , mahogany material is basically the same. The mahogany furniture supplier sells mahogany furniture to mahogany furniture consumer  $S_x$  at the price of  $V_x$ , and mahogany furniture consumer  $S_x$  sells mahogany furniture to the consumer at the price of  $P_x$ .

The mahogany furniture supplier  $F_x$  can choose to abandon the digital supply chain construction and still use the traditional supply chain method (O), or it can choose the digital supply chain construction (T). Whether to choose digital supply chain construction will ultimately form the "OO, OT, TO, TT" four strategy combinations [6].

The demand function is obtained through the Hautelin model: with. Due to the mahogany furniture raw material suppliers and mahogany furniture raw material consumers between a large number of mahogany furniture purchases, so this paper does not consider the mahogany furniture raw material suppliers and mahogany furniture consumers due to the distance generated by the travel cost. It is assumed that the unit cost of mahogany furniture raw material suppliers using the traditional supply chain method is  $C$ . If the digital construction is carried out, an additional total cost is required, but the unit cost can be saved i.e., the impact of the digital method on the competitors is, and carrying out the digital supply chain construction will generate a digital supply chain method spillover to the competitors.

Based on the demand function obtained from the Hauterlin model and the related problem description and assumptions above, the profit functions of mahogany furniture raw material suppliers and mahogany furniture consumers are obtained as follows:

Profit function of mahogany furniture raw material suppliers:

$$R_{Fi} = (V_x - C + \alpha W_x + \beta K_{3-x})D_x - E_x$$

Profit function of mahogany furniture consumers:  $R_{Si} = (P_x - V_x)T_x$

### 3.2 Equilibrium solution of mahogany furniture supply chain

The equilibrium solution is obtained by backward induction, the mahogany furniture consumer determines the price  $P_i$ , and the profit function of mahogany furniture consumer is derived from  $P_1$  and  $P_2$  to obtain  $P_1^*$  and  $P_2^*$  respectively. Raw material suppliers of mahogany furniture determine the price  $V_i$ , and the profit function of raw material suppliers of mahogany furniture

is derived from  $V_1$  and  $V_2$  to obtain  $V_1^*$  and  $V_2^*$  respectively. The mahogany furniture supplier decides whether or not to digitise the supply chain,  $W_i$ , and calculates the equilibrium solution:

Without digital supply chain construction, The optimal solution is:  $P_1^{OO*} = \frac{36t+9C}{9}$ ,

$$P_2^{OO*} = \frac{36t+9C}{9}; T_1^{OO*} = \frac{1}{2}, T_2^{OO*} = \frac{1}{2}; V_1^{OO*} = \frac{9t+3C}{3}, V_2^{OO*} = \frac{9t+3C}{3};$$

(ii) One party carries out digital supply chain construction (here assume that mahogany furniture raw material supplier 1 carries out digital supply chain construction), and the optimal solution is

$$P_1^{OT*} = \frac{36t+9C-5\alpha W_1-4\beta W_2}{9}, P_2^{OT*} = \frac{36t+9C-5\alpha W_1-4\beta W_2}{9};$$

$$T_1^{OT*} = \frac{\alpha W_1 - \beta W_2 + 9t}{18t}, T_2^{OT*} = \frac{\alpha W_1 - \beta W_2 + 9t}{18t}; V_1^{OT*} = \frac{9t+3C-2\alpha W_1-\beta W_2}{3}, V_2^{OT*} = \frac{9t+3C-2\alpha W_1-\beta W_2}{3}.$$

By  $P_1^{OO*} > P_1^{OT*}$  and  $V_1^{OO*} > V_1^{OT*}$ , it can be concluded that the digital transformation of mahogany furniture raw material suppliers can reduce the wholesale price of mahogany furniture raw materials and mahogany furniture finished product price of mahogany furniture raw material processors.

From  $T_1^{OO*} < T_1^{OT*}$ , it can be obtained that the digital supply chain construction of mahogany furniture raw material suppliers can increase the market share share of mahogany furniture.

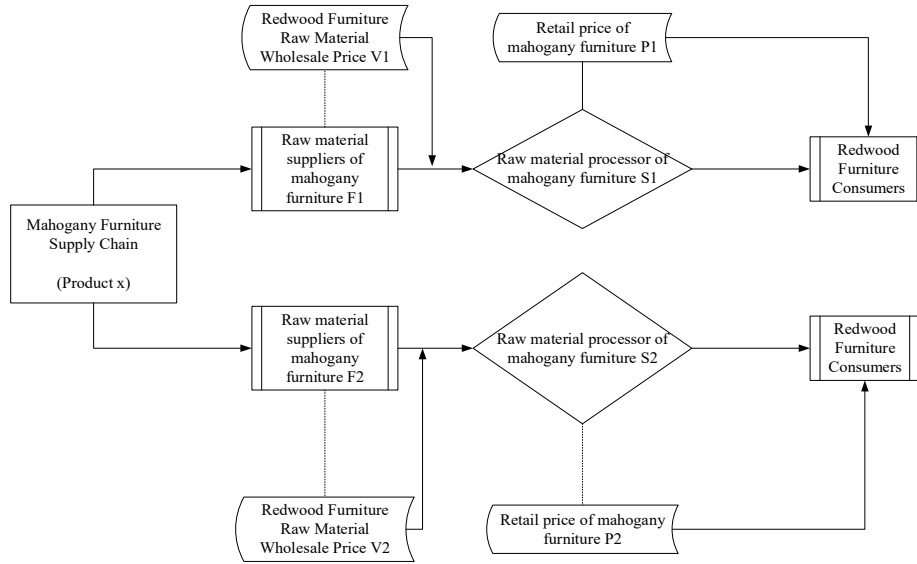


Fig. 1. Supply chain comparison

## 4. Redwood furniture industry digital supply chain optimisation strategy

### 4.1 Build digital supply chain core technology system

The digital supply chain in the field of application of key technologies "artificial intelligence, Internet of Things, 5G communications, block chain, cloud computing" into the mahogany furniture scene, the formation of 5G as a carrier, the Internet of Things as the basis, "data + arithmetic + algorithms" as the core of new Redwood furniture digital supply chain technology support system[7].

### 4.2 Open the integrated digital system platform

Take the digital supply chain platform as the core, build a single-point collaboration mahogany furniture comprehensive cooperative ecosystem, link and connect the entire mahogany furniture industry chain, and promote the digital and intelligent development of the supply chain. Through the integration and optimisation of the digital system, the sharing of data, funds and other elements, as well as the re-optimised allocation of production capacity, in order to improve production efficiency, reduce costs and better meet consumer demand for mahogany furniture, and ultimately to achieve the double enhancement of the efficiency of industrial synergy and the quality of operation[Fig. 2].

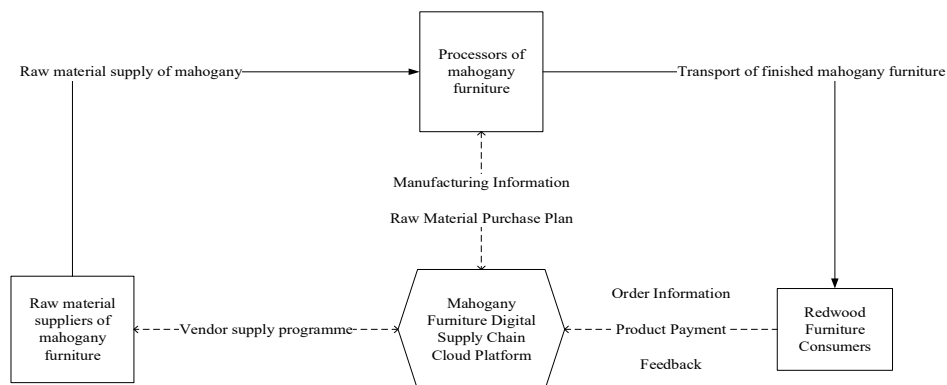


Fig. 2. Mahogany furniture digital cloud platform

### 4.3 Incorporate big model intelligent identification of the whole process information

Through AIGC's powerful language understanding and information processing capabilities, and then with the functions of NLP, CV, intelligent computing and other large models, to achieve

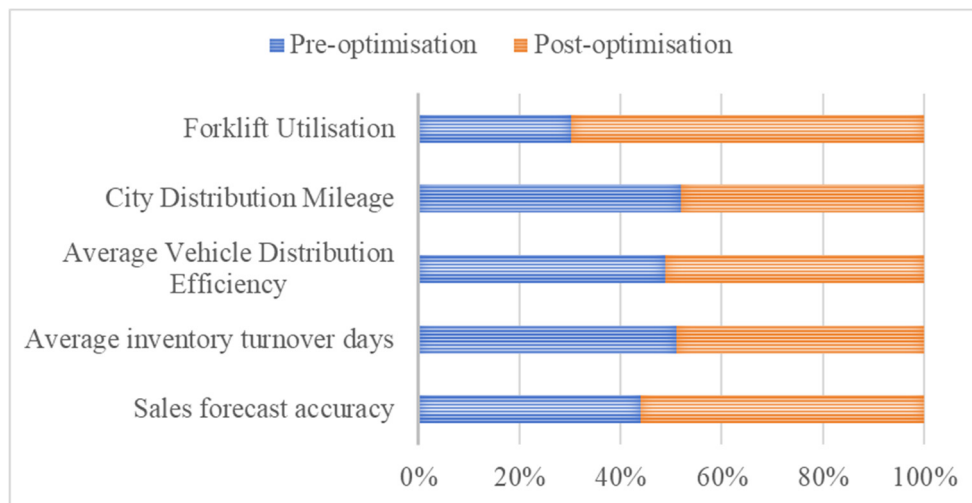
automation and intelligent management of the supply chain of mahogany furniture. For example, in the logistic process of mahogany furniture, with the help of NLP and CV big models to achieve real-time monitoring of the logistics status of mahogany furniture warehousing, and at the same time, with the help of intelligent computing big models to predict and optimise the logistics process, and ultimately to improve the overall efficiency of the logistic link of mahogany furniture, and to achieve the whole process of mahogany furniture tracing and information visualization.

## **5. Effectiveness of digital supply chain transformation at W furniture**

W Furniture Ltd. is a traditional hardwood furniture company specialising in mahogany furniture. With the contraction of the transaction scale of China's real estate new housing market, W Furniture, in order to take advantage of the competition for the share of the inventory market, introduced the HOLINTAI model to analyse and establish the transformation direction of "accelerating the digital, intelligent transformation and upgrading and the integration of on-line and off-line development, and efficient collaboration of the industrial chain and supply chain".

W Furniture in the traditional production mode for OBM (independent production) mode, and the upstream and downstream supply chain, is still "purchase and be purchased" relationship, a product from the mahogany raw materials to the end of the sales, need to go through the plate manufacturers, pressure paste plant, 1-N level distribution agents and other multiple links, information transfer is prone to the "bullwhip effect". "Bullwhip effect", information distortion and level by level amplification, mahogany raw materials mahogany raw material processors need to increase the demand for mahogany furniture production to meet the demand for end sales, but after a number of links in the middle, the feedback to the mahogany raw materials mahogany raw material suppliers may be formed to increase the supply of 8-14% of the supply changes, which in turn cause furniture Inventory backlog occurs.

W home furnishing through digital tools SCM & SRM, PLM, S&OP built "end-to-end full value chain operation system", break the communication barriers of different ports of the supply chain, logistics digital platform to collaborate with the production side, through the national warehouse network, road network and the end of the network, to achieve the effect of cost reduction and efficiency. Data show that through the data supply chain optimization W Furniture mahogany raw material dealers to processors, the effect of the efficiency increased by 36%, and W Furniture relies on a reliable digital supply chain, the average time limit for furniture shipment to the signing of the average time limit of 5.3 days, the fastest 48 hours of high-speed shipment, and at the same time, in the year 2023, 315, May 1, 618, the National Day promotion respectively, delivered 25%, 61%, 40%, and 30% of the blowout year-on-year growth rate. From the speed and effectiveness of W Furniture's digital transformation[Fig. 3], the digital supply chain of mahogany furniture raw material suppliers using the Howlinit model is effective and feasible.



**Fig. 3.** Percentage comparison before and after optimisation

## 6. Conclusion

With the continuous development of science and technology and the wave of digitalisation, the mahogany furniture industry ushered in the construction of digital supply chain. In the mahogany furniture digital supply chain construction process through the introduction of Internet of Things technology, big data analysis and artificial intelligence and other technologies, can be achieved from raw material procurement, manufacturing, logistics and distribution to sales and after-sales service of the whole process of digital management. Greatly improve the production efficiency of mahogany furniture, reduce the cost of mahogany furniture, optimise the supply chain synergy and management of mahogany furniture, improve the quality of mahogany furniture and consumer satisfaction. And through big data analysis, mahogany furniture enterprises can better understand market demand and trends, optimise production planning and inventory management, and achieve accurate supply and pricing strategies, such as customised production, intelligent warehouse management, intelligent logistics and distribution to meet consumers' individual needs. Promote industrial upgrading and transformation, and promote the mahogany furniture industry to the direction of intelligent, green and sustainable development.

This paper also through the use of Haotailin model for mahogany furniture raw material suppliers digital supply chain construction of the two supply chain comparison, concluded that the mahogany furniture raw material suppliers digital construction can reduce the sales price of mahogany furniture to meet the consumer in the price of unchanged based on the mahogany furniture lower price expectations. In addition, the digital supply chain construction of mahogany furniture raw material suppliers can increase the market share and provide ideas for the coordination and collaboration of the supply chain network. However, Hotelling model in the mahogany furniture supply chain digital construction of the argument that too many assumptions, in the actual operation of the supply chain is sometimes difficult to reproduce, in

the next further deepening of the research we also need to expand the optimisation on the basis of the original Hotelling model.

Overall, the construction of digital supply chain will bring more opportunities and challenges for China's mahogany furniture industry, and promote the mahogany furniture industry to a higher level of development, enhance competitiveness and sustainable development.

**Acknowledgments.** This paper is the stage results of the project "Wu Muzhong - Pioneer in the field of AI-based Ergonomic Furniture Design" (Project No. 202211549001S), which is part of China's national college students' innovation and entrepreneurship training programme.

## References

- [1] Liu Xuechun, Han Yujie, Zhang Bei, Li Yajing. Quality management of mahogany furniture enterprises in China. *China Market*, 2020(14):88-89. DOI:10.13939/j.cnki.zgsc.2020.14.088.
- [2] Dong, Y. F. & Yang, D.. (2023). Analysis of the implementation of product standards for mahogany furniture in Dongyang and the development prospect of the industry. *Popular Standardisation* (19), 7-9+12. doi:CNKI:SUN:DZBH.0.2023-19-003.
- [3] Singh, P. K., & Maheswaran, R. (2023). Analysis of social barriers to sustainable innovation and digitisation in supply chain. *environment, Development and Sustainability*, 1-26.
- [4] Xu, M.C.. (2021). Supply chain digitisation problems and responses of central enterprises. *National Circulation Economy* (09), 65-67. doi:10.16834/j.cnki.issn1009-5292.2021.09.021.
- [5] Hotelling, H. (2012). *The collected economics articles of Harold Hotelling*. Springer Science & Business Media.
- [6] Grau-Climent, J., Garcia-Perez, L., Losada, J. C., & Alonso-Sanz, R. (2022). Simulation of the Hotelling-Smithies game: Hotelling was not so wrong. *Communications in Nonlinear Science and Numerical Simulation*, 112, 106513.
- [7] Jingpeng Gao. (2021). Research on Supply Chain Management Problems and Countermeasures of Small and Medium-sized Enterprises in Digital Environment. *Modern Marketing (Business Edition)* (11), 93-95. doi:10.19921/j.cnki.1009-2994.2021-11-0093-031.