Review

Dynamic analysis of the relation between industrial technology and foreign trade of China’s wooden furniture

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China has emerged as the number one furniture exporter globally, and its furniture industry witnesses great development in both quality and quantity. By analyzing the relation between the furniture export and technology of furniture industry, the paper aims at exploring the dynamic path of technology and trade during the development of China’s wooden furniture manufacturers. In this study, the dynamic model of technology and foreign trade is established to explore the interaction between technology and trade and dynamic development path. On the basis of theoretical model, this paper carries out empirical analysis on the data of wooden furniture enterprise, and positions the development stage of China’s wooden furniture industry. The author holds the opinion that lack of technological innovation is the bottleneck for the coordinated development of China’s wooden furniture industry.

Key words: Wooden furniture industry, technology, foreign trade, dynamic relations.

INTRODUCTION

Since 1978, China’s furniture industry harvests rapid development currently ranking the world number one furniture exporter. The development of China’s furniture industry, along with those in other newly industrialized countries, shares many similar characteristics, of which such industries, with the trade orientation, export large quantity of middle-and-low grade furniture products, import necessary technology and equipment and accumulate capitals in the initial development period. However, such trade-oriented development model is not necessarily able to upgrade the whole industry, and an efficient development path on trade and technology will directly impact the development trend of the industry.

Current studies on the relation between technology and foreign trade consist of two schools, the theoretical and the empirical ones. In theoretical studies, the technology and technical diffusion mechanism are introduced into the international trade model for analysis in viewpoint of partial and general equilibrium; such studies generally center on the impact of technical advancement, arisen from different factors, on the industry and foreign trade. In the classical and neoclassical theories, importance is attached to the factor contributions of a country and comparative advantages under the condition of perfect competition. However, the study of Schumpeter (1947) proves functions of technological innovations via trade under the condition of imperfect competition. The factor model of neoclassical theory proposes that the definition on technology should be connected with the specific production process since the technology is an endogenous variable. In empirical studies, the classical theory usually brings technology, human capital, patent quantity and other variables into the regression model to analyze the technical impact, for example, Hughes. K. (1986) replaces the technology with R&D cost and the corresponding personnel, while Fargberg (1988) replaces the technology with patent quantity and R&D cost. Besides, there exists Schmuper’s (1947) Technical Innovation Model and Vernon’s (1966) Product Life Cycle Model. Lots of empirical study attempts to illustrate relations between technology and trade by introducing

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new variables, such as the study of Tang and Jing (1994), Daniel (1993) and Dosi and Pavitt (1990). The current study usually analyzes the interactive relation between technology and trade from the static perspective and the regression model is adopted to study the inter-impact between trade and technology. This paper will analyze the development path of trade and technology in terms of the dynamic interaction relations between technology and trade. Besides, the empirical analysis and policy effects simulation will be carried out on the China’s wooden furniture industry.

TECHNOLOGY AND FOREIGN TRADE MODEL

The industrial development of emerging industrialized economies generally encounters three stages: at the initial development stage, such industries usually import the foreign technology to participate in the production process, take advantage of the low labor cost and introduce foreign technology, equipment and capital with more export of primary products; at the second stage, that is, the take-off phase, based on a certain accumulated capital, such industries take trade-oriented industrial strategies. Relying on scale and cost advantages to export a lot, the industries boast of stronger production capacity and higher production efficiency. However, the overall industrial strength is relatively low and the technological level lags behind. In terms of trade, there are lots of raw material import and great amount of product export and the equipment upgrading is fast; and at the third stage, these industries gradually turn to be capital-intensive or technology-intensive, and such enterprises are capable of innovation for the pursuit of high added-value, as well as high-end manufactured goods, while the corresponding trade performs the reduction of the export of mid and low level products.

The progress emerging industries indicates the coordinated development path of technology and trade. However, with the availability of other development paths, not all industries can successfully complete those three development stages, and for instance, the industries in many developing countries may always remain in the first and second stage. Thanaphol and John (1998) study demonstrates the development path of technology and trade by comparative static analysis (Figure 1), with the X axis representing trade strength and Y axis representing technical strength.

Path one shows the displacement from quadrant II to quadrant IV; this kind of industries puts more emphasis on trade, with deficient technical accumulation; path two shows the displacement from quadrant II to quadrant III; this kind of industry completes three development stages of emerging countries; path three shows the displacement from quadrant II to quadrant I, which indicates that this industry lacks foreign trade development. Tang’s study shows the industry development path in terms of the static comparison and analyzes reasons for the formation of different paths. However, this model fails to explain the dynamic relations between trade and technology.

Technology and dynamic trade model and path analysis

Based on Tang’s model, we establish a dynamic technical trade model consisting of two equations: one is the technical change equation and the other is the trade
change equation, of which, TC refers to technical level and TR trade level. Both variables are comprehensive evaluation value. In the empirical analysis, the replace scores of principal component is given as:

$$
\begin{align*}
\frac{dT_C}{dt} &= (\alpha_1 - \alpha_2) T_C + \alpha_3 T_R \\
\frac{dT_R}{dt} &= \beta_1 T_C + (\beta_2 - \beta_3) T_R
\end{align*}
$$

(1)

$\alpha_1$ refers to technical progress rate, while $\alpha_2$ is technical elimination rate. $\alpha_1 - \alpha_2 > 0$ displays that the technical progress rate is faster than attrition rate; or else, the technical progress rate is slower than attrition rate. The technical progress of the wooden furniture industry is mainly displayed in terms of style design and machining process. Therefore, the technical progress rate is faster and the first order delay is adopted in the model. $\alpha_3$ refers to the trade contribution rate to technology, which can be understood as technical progress led by trade competition. This is a kind of passive technical progress. If an industry has a higher trade’s contribution rate to technology, which can be understood as technical progress led by trade competition, the industry lies in the first or the second stage of the development. $\beta_1$ refer to the technology’s contribution rate to trade, which means that higher technical level will facilitate trade development. When the technical progress is more sourced from the industry’s self accumulation instead of trade, the technical contribution rate to trade will be high, vice versa. $\beta_3$ is the self development of trade, such as change due to industrial scale expansion, investment increase and other factors and $\beta_3$ is trade volume reduction due to trade competition.

### Technology and trade development path analysis

Tang’s study demonstrates the track of trade and technical development without proposing conditions for the emergence of different paths. We shall use the linear dynamics system equation to explain conditions for emergency and motion modes of different paths. Meanwhile, Tang’s model is extended for such an industry in which technical and trade contraction may possibly take place in a relatively large time span:

Convert the equation into a matrix:

$$
\begin{bmatrix}
\frac{dT_C}{dt} \\
\frac{dT_R}{dt}
\end{bmatrix} =
\begin{bmatrix}
\alpha_1 - \alpha_2 & \alpha_3 \\
\beta_1 & \beta_2 - \beta_3
\end{bmatrix}
\begin{bmatrix}
T_C \\
T_R
\end{bmatrix}
$$

(2)

Where $A = \begin{bmatrix}
\alpha_1 - \alpha_2 & \alpha_3 \\
\beta_1 & \beta_2 - \beta_3
\end{bmatrix}$, trace of $A$: $p=\text{tr}A$; determinant of $A$: $q=\text{det}A$.

The path 1 and 2 correspond to the common development path presented by Tang, while the path 3, 4 and 5 are not in Tang’s analysis (Figure 2). Under $p^2 - 4q > 0$, there comes out the path 2, 3 and 4, of which, it is path 2 when under the condition of $p>0$, and in
such scenario, the technology and trade are divergent, while their growth rate depends on the characteristic root. When $p=0$, the corresponding path is path 2, with one of the aforementioned two factors (technology and trade) been divergent along with the other been convergent, and such convergent term means insufficient input, while affecting the development speed. When $p<0$, both the technology and trade are convergent, which means that the industry is either in the late stage of development or there is competition failure due to inadequate technical or industrial inputs. Under the $p^2 - 4q < 0$, the study brings forth paths 1, 5 and 6, of which, when $p>0$ it is to be path 1, with the technology and trade in spiral development; when $p=0$, it corresponds to path 6, the technology and trade fluctuates within a certain interval; and when $p<0$, the technology and trade are spirally divergent. The Dynamic System may classify the path 1, 2 (divergent) into one group, while the path 4, 5 (convergent) into the separate one. Rightly in Tang's analysis, the path 1 and 2 are the common development path for technology and trade; and the characteristic of such path categories is that, with time, change in technology and trade will move away from the equilibrium point, yet with various growth rates according to different parameters. The path 4 and 5 are the development mode under industrial collapse, with the possible cause of either later industrial phase or another case that the foreign competitors have already entered the China’s market and defeated national industries. Finally, the path 3 or 6 represents an unsustainable development model.

Parameters in the relevant equation will determine the development path for the industrial technology and trade. As for the selection of a specific development path, it is dependent in characteristics of the industry itself, as well as development status. The policy or strategy implication of such technology and trade equation contains that various development paths are not everlasting, while such paths can be alternative or transformed through the change of industrial policies.

**EMPIRICAL ANALYSES ON RELATIONS BETWEEN TECHNOLOGY AND TRADE DEVELOPMENT OF CHINA’S WOODEN FURNITURE INDUSTRY**

Although China has become the world No.1 furniture exporter, the current development of furniture industry still holds that both the backward technology and the overall industrial level are not so high. Based on the technology-trade relation model, this section is to study the present status of technology and trade development of China’s wooden furniture industry, analyze its development path and predict its future development trend.

**Model verification and estimation**

With the application of differential equation in the aforementioned analysis, yet in empirical analysis, we change the technology-trade equation into the difference equation, which basically has the same attributes as those in the aforementioned differential equation. For the definition of technical and trade variables, we apply three variables as main components. The technical level of the China’s wooden furniture industry is substituted with the micro-electronics control equipment, new product sales revenue and fundraising total of technical R&D expenditure. The industrial trade should be defined by American market because about half of China’s wooden furniture products are exported to US, which additionally has a quite strict in aspects of market order and product specifications. Therefore, the trade behavior of China’s wooden furniture in America can represent the overall situation such an industry. We select the trade volume of China’s wooden furniture exported to America, the proportion of such export to US in the corresponding world trade volume, and China’s market coverage in American wooden furniture market to display trade status of China’s wooden furniture. In the analysis, we carry out the standardization on data totals and use the standardized data as main components to obtain the overall score of the technology and trade of China’s wooden furniture industry, and then, the regression analysis is carried out. In the trade equation, we add per capita GDP in the US as an external variable (this variable also is treated with total standardization). The system of equations is as follows:

$$TC(t) = a_1 TC(t-1) + a_2 TR(t-1) + \varepsilon_1$$

$$TR(t) = b_1 TC(t-1) + b_2 TR + b_3 Y_t + \varepsilon_2$$

Where, $TC(t), TR(t)$ are technical and trade value at t period. $Y_t$ is per capita GDP in America. $a_1 = \alpha_1 - \alpha_2$, $a_2 = \alpha_2, b_1 = \beta_1, b_2 = (\beta_2 - \beta_3), \varepsilon_1, \varepsilon_2$ are random error terms. For analytical convenience, we don’t differentiate the trade changes due to technical elimination rate and competition extent. Through the method of least squares, it is estimated as:

$$TC(t) = 0.0618 - 0.1173 T C(t-1) + 2.681 TR(t-1)$$

$$R^2 = 0.9769, F = 169.1, DW = 2.135$$

$$TR(t) = -0.465 - 0.158 T C(t-1) + 1.935 T R + 5.582 Y_t$$

$$R^2 = 0.9943, F = 409, DW = 2.0847$$

The relation equations of both technology and trade are obtained, both having a high degree of fitting, except the verification failure of the technical renewal term in the
technical equation. From the equations, we can find out that the technical renewal value has a negative impact on the current value of both industrial technology and trade, which indicates that the technical self-accumulation of China’s wooden furniture is not high. Besides, the high trade contribution rate to technology indicates that the industrial technical progress is sourced from international market competition. Such technical progress mode will make China’s wooden furniture industry just a technical follower instead of the technical creator. The China’s wooden furniture industry has a strong reliance degree on US per capita GDP, which demonstrates that the export of China’s wooden furniture is easily susceptible to American economic volatility. In general, the equation estimation and variable symbols fundamentally meet our hypothesis, namely both equations fitting highly.

For China’s wooden furniture industry, the aforementioned relation equations illustrate the characteristics of its technical advancement: the technical progress is rooted in trade, while the technical self-accumulation is inadequate. Also, consistent with the current status of China’s wooden furniture industry, such aforementioned characteristics reflect that contrary to the backward industrial technology, the actual technical progress of China’s wooden furniture industry is quite rapid. However, in a large part of China, such technology mainly stays in design innovation, and such technical progress in the form of trade import witnesses China as the only imitator of overseas industrial peers. Therefore, the current China’s furniture industry has a strong capacity in processing, while its abilities in independent innovation and product R&D are insufficient.

Predications and path analysis on relations among the technology, trade and development of China’s wooden furniture industry

We already estimate and put forward the technology and trade development equation of China’s wooden furniture industry, so here, we will project on its technology and trade development path, and analyze the impact of American economy fluctuations on the technology and trade of China’s wooden furniture industry. According to experience, the annual US per capita GDP in the US grows by 2%. Based on such figure, we shall predict the future trade and technology development path (Figure 3a).

The predicted results are consistent with the optimal development path described by Tang. As shown in Figure 3, after a time span, the technical development pace may be faster than that of the trade, which yet does not mean
that the China's wooden furniture industry has a higher technical level, because such industrial technology is rooted in the learning from competitors during trade. In the wooden furniture industry, the design innovation takes a large proportion in the technical innovation. Although such simple imitation enhances the overall industrial technical level, which does not mean a superior position in competition. The rapid foreign trade growth of China's wooden furniture mainly benefits from overseas markets and expansion of China's industry scale. The reason for it is that China's wooden furniture has comparative advantages, such as low labor cost and so on. When the labor cost edge gradually decreases, the self development of China's industry and function of overseas market demand will weaken. The foreign trade promotes technical improvement of China's wooden furniture industry in respects to equipment upgrading and research expense increase. However, this industry still lacks independent innovation capacity, because under the simulation of trade and technological path according to different US per capita GDP growth rates, we find out that this industry is extremely sensitive to overseas market volatility. Figure 3b and d show the per capita GDP development level in the US under 2 and 5% growth rate, the change is not so much. The technical trade path is compared with it (Figure 3a); the cross shape stands for path at 2% growth rate, while the grain shape stands for path under 5% growth rate. We may find out that the industry technical progress is easily susceptible to overseas market volatility.

Path function simulation in the relation among technical innovation, technology and trade of China's wooden furniture industry

Under the current transformation period of progress, China's wooden furniture industry achieves a certain scale and technical power through world trade while weakening its industrial cost advantage. In such circumstances, technical upgrade and innovation capacity play a vital function. Here, simulations are made: after changes of the progress rate by technical innovation (-0.1173 turning into 0.001) and technical contribution rate to trade (-0.158 turning into 0.01), how will then the technology and trade paths respond to the different US per capita GDP growth rates (Figure 3c)? By the corresponding results, the technical innovation makes the technology and trade develop faster than previous status. Technical innovation plays two roles on the system: on one hand, such innovation requires the industry to fasten its self-accumulation of technology, and on the other hand, the technical progress lifts up the industrial competitiveness and hence improves technology's contribution on trade. In other words, while quickening self-aggregation, the technical innovation also speeds up under the impact of trade. The path under the interaction between technology and trade is much quicker than the original one. Also, the technical innovation alleviates the impact of US per capita GDP fluctuation. In Figure 3a, the path for 2% growth rate is only half of that of the 5% growth rate, and the technical innovation makes slight variation between two new paths, respectively under 2 and 5% US per capita GDP growth rate.

Conclusion

Through the establishment of dynamic system model of trade and technology, this paper analyzes the different development paths and formation conditions for technology and foreign trade and carries out empirical analysis on the technical and trade development of China's wooden furniture industry. Based on the analysis, we find out that the overall technical level of China's wooden furniture industry improves rapidly and the foreign trade development is fast. However, this development mode heavily depends on external factors: the technical progress of the China's wooden furniture industry is sourced from the study on competitors during foreign trade, while the innovation capacity is inadequate; the foreign trade of wooden furniture is susceptible to American economic fluctuations; the US per capita GDP has a huge influence on trade and technology. After years of development, the primary technical level of China's wooden furniture industry increases and its industrial scale expands. However, such development only stands on the second development stage. Low product added value and weak innovation capacity restrict the development of foreign trade of the China's wooden furniture industry. The independent technical improvement is an efficient means to make breakthrough on such development bottlenecks. In order to realize the coordinated development of both technology and trade, the industry should not only actively learn from its competitors in the competition of the international market, but also enhance its own technical innovation capacity and the conversion capacity from technology to product. Future studies should focus more on the analyzes of factors affecting technical innovation, and deeply studying the function modes and different effects of industrial policies and strategies.

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