Analysis of the Relationship between Research & Development Innovation and Export Trade Level in Pharmaceutical Manufacturing Industry

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Abstract: Objective: to explore the interaction between research & development (be abbreviated to R&D below text) innovation and export trade level in China's pharmaceutical manufacturing industry. Methods :select 10 pharmaceutical enterprises in China's pharmaceutical manufacturing industry， and use super-efficiency DEA model to measure R & D efficiency as the representative index of R & D innovation. The VECM-based Granger causality test method is further adopted to explore the interaction between R & D innovation and export trade level. Results: when the research lag period is 2-4 years, there is a mutual relationship between R & D innovation and export trade level in China's pharmaceutical manufacturing industry, and the change of export trade level of enterprises in the short term is restricted by the long-term equilibrium relationship of R & D innovation. Conclusion: in the process of development, Chinese pharmaceutical manufacturing enterprises should not only pay attention to the development of export trade, but also cannot relax the improvement of R & D innovation level of enterprises, and continue to cycle development to achieve the relative balance of their common progress.

1. Introduction

The biotechnology industry with pharmaceutical manufacturing as the main industry is regarded as the priority development industry in the 21st century by many developed countries, such as Japan and the European Union. Pharmaceutical manufacturing industry is recognized as a high-input, high-risk, long-cycle industry. High investment R & D activities are the prerequisite for industry entry and sustainable development of enterprises. Therefore, enterprises attach great importance to the research and development of medicine. Research and development investments by the world's largest pharmaceutical companies account for 9-18% of turnover, according to the data, and the ability of large pharmaceutical companies to continuously engage in technical mergers and acquisitions to control the market by monopolizing technology to obtain excess profits [1].

As a developing country, China's pharmaceutical manufacturing industry started late. In recent years, with the increasing investment in drugs and R & D innovation, the growth rate of R & D in China is 27.5.Since 2004, research and development investment of pharmaceutical and biological listed companies has risen rapidly, from 1052.1 million yuan in 2004 to 2 billion yuan in 2016. Although R & D investment has increased rapidly, it is still far below the world average. Because of the limited R & D capacity, although China has become the third largest pharmaceutical market in the world, the proportion of innovative medicine with independent intellectual property rights is very low, only 18%, which is far lower than that of the United States, Europe and Japan. Insufficient R & D investment and low efficiency are important problems faced by pharmaceutical enterprises. Meanwhile, China's total exports of pharmaceutical products have grown steadily, but at a relatively low rate.

Currently, the main research results of R & D innovation innovation and industrial trade level are summarized. The growth and promotion of industrial export trade level depend on innovation-driven support. Porter's four-stage theory of industrial export trade level, That is, the growth stage of industrial export trade level is divided into four stages: factor-driven stage, investment-oriented stage, innovation-oriented stage and capital-oriented stage are the most obvious examples of using innovation stage. Sanyal (2004) use OECD bilateral trade data, For 18 industries comprising five member countries within the OECD, Having studied the impact of R & D activities and technological opportunities on export trade during the period 1980-1998, Turns out, At the national level, R & D innovation represented by R & D intensity is positively related to bilateral trade flows, And by industry classification, R & D innovation mainly affects the export trade of high-tech industries. Motobbio (2005) for nine typical developing countries, including China and India, Using data from the United Nations Commodity Trade UNCOMTRADE Database and patent data from the USPTO and Trademark Office, The relationship between R & D innovation and export trade is expounded from the empirical analysis of countries and industries, It also shows that even less developed countries can benefit from R & D innovation in export trade, And this reverse promotion of R & D innovation progress.

Zhiyong Kang(2011) from the perspective of scale heterogeneity, Research on independent innovation activities of enterprises, Enterprise size plays a moderating role in the impact of export trade on technological innovation, The larger the size of the enterprise, the more obvious the promotion of independent innovation, The smaller the enterprise export, the more inhibitory effect. Fengchun Li(2013) based on the perspective of corporate strategic objectives, Using data from a survey of 14,000 high-tech companies in China in 2005-2008, In pursuit of short-term profit maximization, "Learning in Export" will have a significant inhibitory effect on independent R & D; Companies that pursue long-term performance, Its "export learning" strongly promotes independent R & D. Feng Shi(2016) used panel data model to obtain the conclusion that there are regional differences in the effects of export trade on technological innovation. It shows the strongest pattern in the east, the second in the middle and the weaker in the west. Guansheng Yu (2011) regression of time series data between 1986 and 2008 based on the system estimation method of simultaneous equations, it is found that there is a mutually reinforcing relationship between export trade and technological innovation.

Many scholars have made some research on the relationship between R & D innovation and export level, and have obtained corresponding research results. For the pharmaceutical manufacturing industry, whether there is a similar relationship between R & D innovation innovation and export level, the research results are very limited. This paper attempts to expound the relationship between R & D innovation and enterprise export level in pharmaceutical manufacturing industry through empirical research.

2. Research Design and Data Selection

2.1. Research Design

The research of this paper includes two parts: one is to use radial super-efficiency model to calculate the efficiency of R & D innovation in enterprises, the other is to use VECM Granger causality test to study the relationship between export trade and R & D innovation efficiency.

The DEA model established belongs to an accurate evaluation method which can simultaneously multiple inputs and multiple outputs. As it happens, the R & D innovation of pharmaceutical manufacturing enterprises also belongs to the dynamic process of more than one hour of input and multiple outputs. Therefore, when the comprehensive calculation is needed to obtain the efficiency index of each unit, it can be realized by establishing the DEA model. DEA model is measured; the DMU is also selected and classified. When more than one DMU is fully valid (the efficiency value is equal to 1), the traditional DEA method cannot be further evaluated. The efficiency value measured by the advanced super-efficiency DEA model is not limited by the maximum number. Unlike the traditional DEA model, it can only get the efficiency index between 0-1 and can be greater than 1 [2].Therefore, selecting the super-efficiency DEA model for efficiency measurement can also subdivide multiple effective DMU and sort them to support the selection of optimal benefits.

Granger causality test loss error correction model based on VECM (Vector Correction Model). By inserting error correction into the established VAR model, cointegration test and error correction model are combined in order to obtain more accurate test results [3]. Meanwhile, only with the help of Granger causality test can the complex results obtained by VECM be simplified.

2.2. Selection of R & D Innovation Data

First of all, select 10 listed enterprises in China's pharmaceutical enterprises, which have entered the top 50 of China's comprehensive strength list of drug research and development for 4 years in a row. In order to ensure that the sample data are sufficient and effective, the 10 pharmaceutical enterprises selected are listed for more than 5 years and carry out uninterrupted export trade within 5 years. Each of the ten companies is represented in A、B、C、D、E、F、G、H、I、J ten letters below.

Secondly, the selection of investment index of technological innovation. All the data selected in this paper are from the annual reports of the above 10 domestic listed pharmaceutical enterprises (2015-2019). Because the relationship between R & D innovation and export trade is studied, and R & D innovation is influenced by internal and external factors, this paper selects the super-efficiency DEA model of comprehensive analysis to study the time series. And finally get the R & D efficiency index that can measure R & D innovation.

The measurement of R & D efficiency needs the support of R & D input and R & D output index. The input index selected here is total R & D input (including cost R & D input & capitalized R & D input)(billion yuan) and the number of R & D personnel (people); the output index is the number of drugs (products) submitted to regulatory authorities for approval, registration or production approval during the reporting period [4].

2.3. Data Selection on Export Trade Levels

This paper chooses the export orientation degree as the index to measure the export trade level. That is, export trade income / main business income expressed. The export value chosen by most scholars is not used to represent the export trade level of the enterprise because: this paper selects 10 domestic pharmaceutical enterprises to do the research object, although its comprehensive R & D ability ranking is similar [5]. However, the scale and export value of enterprises vary greatly. Therefore, in order to eliminate the influence of other factors, the export orientation degree (F) obtained by the ratio of export trade income to total sales income is selected to judge the export trade level of enterprises. The export trade income and total sales income obtained from the annual report of 10 pharmaceutical enterprises from 2015 to 2019.

3. Empirical Research

3.1. Measuring R & D Efficiency (E)

Technical innovation evaluation adopts R & D efficiency index. A radial super-efficiency DEA model is selected to calculate the R & D efficiency of enterprises, because this paper focuses on the change of export orientation caused by increasing R & D funds and R & D personnel in pharmaceutical manufacturing enterprises. Instead of the increase in the proportion of exports caused by external factors.

Through the use of DEA auxiliary software, the radial superefficiency model is selected to run, and the results of R & D efficiency (E) analysis of the available results are shown in Table 1.

Table 1. Efficiency in R & D of 10 pharmaceutical companies in 2015-2019(E)

	A	B	C	D	E	F	G	H	I	J
2015	0.040	0.924	0.204	0.668	0.043	0.474	0.114	0.068	0.168	0.335
2016	0.119	1.000	0.351	0.848	1.000	0.935	0.019	0.075	0.044	0.242
2017	0.088	0.138	0.273	0.312	0.366	0.188	0.164	0.072	0.188	0.317
2018	0.033	0.131	0.263	0.437	0.375	0.340	0.123	0.112	0.784	0.266
2019	0.027	0.219	0.124	0.232	0.458	0.494	0.143	0.113	0.301	0.202

3.2. Measurement of Export Orientation (F)

The formula for calculating export orientation is export trade income / total operating income, that is, the annual F value of F=X3/X4, enterprises is shown in table 2 below.

Table 2. Export orientation of 10 pharmaceutical companies in 2015-2019(F)

	A	B	C	D	E	F	G	H	I	J
2015	0.038	0.134	0.044	0.014	0.077	0.694	0.007	0.001	0.010	0.001
2016	0.039	0.145	0.086	0.030	0.073	0.675	0.006	0.007	0.010	0.002
2017	0.046	0.181	0.119	0.029	0.072	0.606	0.015	0.015	0.012	0.002
2018	0.037	0.237	0.120	0.045	0.083	0.623	0.013	0.067	0.012	0.003
2019	0.027	0.301	0.125	0.070	0.077	0.624	0.013	0.086	0.132	0.005

3.3. VECM - based Granger Causality Test

The time series of E (R & D efficiency) and F (export orientation degree) are selected and tested in VECM model. The variables should be smoothed before the causality test is really started, so that the sequence passes the unit root test by the difference transformation [6]. Granger further proves that if a pair of I (1) sequences have a cointegration (co-integration) relationship (that is, for two nonstationary homogeneous single integer sequences, their linear combinations are stationary sequences), there must be a causal relationship in at least one direction between them.

3.3.1. Unit Root Test

A more rigorous summary (multiple) test method is selected to transform the stationarity test of data sequence into the test of unit root. When the probability of ADF and LLC test is less than 0.05, it can be considered that the sequence rejects the hypothesis that there is a unit root and belongs to a stationary time series [7].The test results show that the original sequence LLC test probability of R & D efficiency (E) and exit orientation (F) are less than 0.05, but the ADF test probability of both is more than 0.05.

The results show that the LLC and ADF test probability values of the first order difference sequences of R & D efficiency (E) and exit orientation (F) are both 0 [8].The test results consider that the R & D efficiency (E) and the exit orientation (F) of the time series belong to the first order single integer sequence. Therefore, the necessary cointegration tests for R & D efficiency (E) and export orientation (F) sequences can continue.

3.3.2. Cointegration Test

Here is the Johansen cointegration test method [9]. First, this paper establishes a VAR model to determine K, optimal lag order. According to the results, the optimal delay order K is 4, but the cointegration test is a constrained VAR. So, the true lag order should be the optimal lag order determined VAR the model (K-1), that's 3 [10]. Second, Johansen cointegration test is continued. At 95% confidence level, there is a cointegration relationship between the two primary variables, a long-term stable cointegration relationshipexists between R & D efficiency and export orientation of pharmaceutical manufacturing industry. The regression equation was established by cointegration test F= E*1.27.According to the regression equation, the following assumptions are made.Assumption 1 is that the corresponding R & D efficiency increased by 1.27% when each 1% increase in the export orientation. Assumption 2 is that the export orientation increased by 0.79% when the corresponding R & D efficiency increased by 1%. Further Granger causality tests are needed to determine which hypothesis holds.

3.3.3. Granger Causality Test

According to the Granger causality test, the results show that the Granger causality between R & D efficiency (E) and export orientation (F) is different [11]. When the lag order is 1, there is no causal between R & D efficiency (E) and export orientation (F).When the lag order is 2, R & D efficiency (E) and export orientation (F) can be considered as Granger reasons at least 97.77% confidence level. R & D efficiency (E) and export orientation (F) can be considered as Granger reasons at least at 97.55% confidence level if the lag order is 3.When the lag order is 4, R & D efficiency (E) and export orientation (F) can be considered as Granger reasons at least at 98.88% confidence level. So, It can be considered that the corresponding R & D efficiency increased by 1.27 at a delay of 2,3,4,just 1% increase in export orientation. When 1% increase in R & D efficiency, the export orientation increased by 0.79% (1/1.27) respectively.

4. Conclusions

Through unit root test, Johansen cointegration test, error correction model establishment and Granger causality test, the following conclusions can be drawn.

In the long run, there is a stable equilibrium relationship between technological innovation and export trade of pharmaceutical manufacturing enterprises in China. Within three years (including three years), the export trade and technological innovation of enterprises interact with each other and have a positive effect. However, the level of export trade does not significantly stimulate the level of technological innovation. For each increase in export trade level, the level of technological innovation only increases by 0. In three years and longer (including three years), the increase of the level of technological innovation of enterprises will significantly lead to the increase of the level of export trade of enterprises, that is, for each increase of the level of technological innovation, the level of technological innovation of enterprises will increase by 1.27. For the short term, the medium coefficient of the EF formula obtained after error correction is -1.15, that is, the change of technological innovation level of Chinese pharmaceutical manufacturing enterprises in the short term is restricted by the long-term equilibrium relationship of export trade variables.

In general, the innovation level of Chinese pharmaceutical manufacturing enterprises has a positive pull effect on export trade activities, and this pull effect is more significant with the increase of time. The promotion of export trade activities to technological innovation level is more obvious only within two years after the income of innovative products. The combination of theoretical research and empirical research will find that both of them are very good proof of each other's correctness, that is, R & D efficiency and export trade ability in pharmaceutical manufacturing industry are closely related. This is true even from very micro individual enterprises.

Therefore, it is very feasible to improve the R & D ability of enterprise innovation, try to climb the industrial chain from the inside, and help our pharmaceutical manufacturing industry to improve the international competitiveness.

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