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Paper:

Innovation Path of Manufacturing Enterprises and Strategies for Transformation and Upgrading in China

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The economy is facing transformation and technological upgrading, which is particularly imperative to upgrading the real economy in China. It is well known that manufacturing is the core of the real economy. Therefore, insights into the innovation path of manufacturing enterprises are helpful in understanding problems that exist, and they suggest future strategies in manufacturing innovation. In this paper, based on historical data from 2000 to 2014, Bayesian methods and time-varying parameter dynamic regression models are used to identify the innovation path of manufacturing enterprises. This paper shows that the relevant research departments within firms need to improve the efficiency of research and development (R&D) institutions and mobilize the enthusiasm of full-time R&D personnel to provide a solid foundation for innovation, and transformation, and upgrading of the manufacturing industry. The paper also shows the need to improve the efficiency of R&D investment and new product R&D investments. In addition to independent R&D, manufacturing enterprises should also increase the adoption of foreign technology into their own manufacturing processes. Finally, some future strategies with regards to transformation and upgrading are discussed.

Keywords: manufacturing enterprises, enterprise transformation, innovation path, research and development, capital investment

1. Introduction

The manufacturing industry is the mainstay of the national economy, the pillar industry of the national economy, and the leading sectors for economic growth. It is also the main channel to increase employment, and international competitiveness. The manufacturing industry can be considered "the main battlefield" of scientific and technological innovation, and is an important source of maintaining national competitive strength and innovation vitality. The scientific and technological innovation factors directly affect the speed, quality, and efficiency of a country's economic development, and determine the international division of labor and status of the country in the process of globalization.

At present, the global industrial competition process is undergoing a major adjustment. Developed countries have implemented reindustrialization strategies that are reshaping the competitive advantages of their manufacturing industries. Some developing countries actively participate in the global industrial division of labor to facilitate the transfer of industries and capital, and to speed up the planning and layout of their industries. In particular, breakthrough innovation [1, 2] is more concerned with relative incremental innovation. China is the world's largest manufacturing country, and manages the world's largest manufacturing share in terms of weight. China needs to develop manufacturing industry, the implementation of innovation driven development strategy, accelerate economic transformation and upgrading its technological level to achieve the dream of becoming a global power with strategic global significance. However, the Chinese manufacturing industry faces challenges from developed countries and other developing countries, and must turn these challenges into opportunities by having the determination and confidence required to develop a stronger manufacturing industry, through innovation and technological upgrading.

Coe, Helpman, and Hoffmaister [3] uses 22 cases of OECD national data to carry out an empirical study testing the theory of Grossman and Helpman [4]. The paper finds that, the establishment of an international research and development (R&D) spillover model based on endogenous growth model, the share of imports of trade partners R&D estimates are weighted by import trade overflow R&D, research on the relationship between foreign R&D spillover and TFP, the import trade channels to obtain R&D are important factors to promote the importation of technical progress. Cohen and Levinthal [5] show R&D has a "double effect" on technical progress, that is, a direct role in promoting a new technology and another role in the formation of "absorption capacity," which promotes spillover into other R&D processes.

Kinoshita [6] believes that R&D investment paly an innovative role and has a learning effect, and finds that the role of domestic R&D activities for enhancing the absorptive capacity of enterprises is far greater than its role in technological innovation.

In this paper, we argue that the development of the Chinese manufacturing entrepreneurship is currently facing a severe challenge of "two-way extrusion" from developed countries and other developing countries. China must transform this challenge into an opportunity by creating a more solid foundation through innovation and technological upgrading. It is necessary to analyze the impact of the innovation path on the industrial value added in the process of transformation and upgrading of manufacturing enterprises, as well as on the new product sales revenue in the process of transformation and upgrading of manufacturing enterprises in China.

This paper makes several contributions to the manufacturing entrepreneurship literature. First, our findings provide evidence that R&D institutions of some manufacturing enterprises are too complex and inefficient. Second, our findings provide evidence that there are problems in the use of funds, and R&D personnel enthusiasm may not be high. Thirdly, our findings provide evidence that lack of innovative capacity of enterprises wastes a lot of money, thus these enterprises need to upgrade in a timely manner by adopting. Finally, our results suggest some implications for innovation policies, and we provide a strategy for Chinese manufacturing industry, as well as prospects for the future.

Our results imply that relevant research departments within firms in China need to improve the efficiency of their R&D institutions, and mobilize the enthusiasm of full-time R&D personnel to provide a solid foundation for innovation, transformation, and upgrading of the manufacturing industry. The efficiency of R&D investment and new product R&D investment needs to be improved as well. Finally, in the current context, it is necessary to continue to support the adoption of technology.

The rest of this paper is organized as follows. Section 2 reviews the relevant literatures and establishes the theoretical framework leading to our estimation hypotheses. Section 3 provides a description of our empirical model, data set, and variables. Section 4 reports and discusses the econometric results. Finally, Section 5 reports our concluding remarks and presents strategies moving forward with regards to transformation and technological upgrading.

2. Literature Review and Hypothesis

Schumpeter [7] shows that economic change and growth is attributed to innovation activities. Solow [8] shows through an empirical test that economic growth of developed countries is to a large extent due to technological progress, which is brought about by R&D innovation. Howitt and Aghion [9] points out that economic growth is brought about by a series of random quality improvements or vertical innovation, which itself comes from R&D activity with uncertain results. Romer [10] presents the endogenous growth theory, which states that economic growth is not affected by the accumulation of capital; technological progress is independent of outside capital; and R&D incentives determine the rate of economic growth and promote long-term economic growth. At the enterprise level, Chen [11] finds that the output elasticity of R&D is about 0.24 by using a medium-sized manufacturing enterprise panel data with 5451 observations in China for the period of research between 1997 to 1999. Zhang, Zhang, and Zhao [12] use a stochastic frontier production function (SFA) analysis on a 1995 cross-sectional data of 8341 large- and medium-sized Chinese enterprises to investigate R&D efficiency issues.

2.1. Research and Development

In the manufacturing industry, some key products and key components of the technical content and level of the continuous development process are important, in achieving upgrade. The improvement of the technical level is mainly achieved through two ways: the introduction of technology and independent research and development R&D. Romer [13] states that the technological progress rate of some countries is low because their investment in the knowledge production sector is insufficient, and thus, these countries are stuck at a low level of long-term growth. R&D investment endogenous growth model is the most widely used to describe the basic model of technological progress described above.

The Chinese manufacturing industry faces the competition from industries in both developed countries. Although the scale of the Chinese manufacturing industry has been ranked first in the world, its level of innovation is not high and it is characterized by a long-term existence of heteronomy, industry overcapacity, and high energy consumption. In the context of this new global competition, the Chinese manufacturing industry must attempt to improve innovation capability, eand quipment manufacturing enterprises should increase investments in scientific research and personnel, product quality, and craftsmanship. Some scholars believe that there is a tension between independent research and development of manufacturing enterprises that are introducing new technology introduction and entities that carry out independent research and development (i.e., that there is a "crowding out effect"). However, more scholars believe that the two share a "complementary" relationship. Empirical tests of different countries and different economic characteristics of the enterprise have led to the conclusion that there is a positive link between the two. Manufacturing enterprises, if their technological capacity is high, will introduce and imitate advanced technology and develop technology for key products or parts, so that they can win in the market.

Schmookler [14] was the fist study to consider patents as a direct consequence of technological innovation. Bound [15] uses a data of large- and medium-sized manufacturing enterprises listed in the U.S. to analyze technological innovation investments and patents and finds a significant positive correlation between investments and patent technology innovation of enterprises. A similar conclusion was also presented in Beneito and Sanchis-Llopis [16]. Boeing, Mueller, and Sandner [17] find that patents are the main output of enterprise R&D activities, and enterprises spending on technological innovation activities gives the enterprise an excess return on the long-term intangible assets.

Reviewing the existing literature leads us to two hypotheses, which will be tested in our paper.

Hypothesis 1: In China, the number of R&D personnel did not result in any significant positive impact in terms of technological improvement in manufacturing enterprises.

Hypothesis 2: Having too many independent non-enterprises R&D institutions is not conducive to increased innovation and transformation of Chinese manufacturing enterprises.

2.2. Transformation and Upgrading

Humphrey and Schmitz [18] believes that an upgrade is the process of enterprises obtaining technical and market capacity, and presents four modes of upgrades from the perspective of global value chain: clear process upgrading, product upgrading, functional upgrading and cross industry upgrading. Broadberry [19] notes from the productivity performance perspective that the development of manufacturing is a process of ups and downs based on a comparative analysis of UK, US, Germany, and other countries. Kaplinsky, Morris, and Readman [20] points out that the process of industrial upgrading and innovation process is that more emphasis on innovation and more competitive rivals who are more efficient than the problem, but only a form of industrial upgrading.

Reviewing the existing literature leads us to a hypothese, which will be tested in our paper.

Hypothesis 3: Despite continued R&D investments and R&D of new products, the transformation and upgrading of China's manufacturing enterprises is insufficient.

The key motivation behind industrial upgrading is the pursuit of profit, which is influenced by factors such as factor endowments, technology level and agglomeration effects. Intra-industry upgrading can be considered a process of resource optimization and adjustments between different nodes along the value chain, and the upgrading of the industry, the reallocation of resources between different industries. Brandt [21] shows that from a micro perspective, industrial upgrading is the process of advancement of higher value-added sectors of the economy by analyzing the promotion the value chain form.

Reviewing the existing literature leads us to a hypothese, which will be tested in our paper.

Hypothesis 4: In the absence of independent innovation and economic downturns higher levels of investment in technology generation are favorable.

In this paper, industrial upgrading refers to change in labor distribution among different industries, the gradual transition from low-skilled physical labor to high-skilled intellectual labor, and the increased share of R&D personnel as the economy develops. Following these changes, other changes will take place indirectly such as increase in industrial production level, the number of patents, and the development of new products.

3. Empirical Model, Data and Variables: Descriptive Analysis

3.1. Empirical Model, Data and Variables

The data used in this paper are drawn from the China Statistical Yearbook and China Statistical Yearbook on Science and Technology for the period 2000-2014. This is an annual data compiled by the China National Bureau of Statistics and the Chinese Ministry of Science and Technology, and presents data from manufacturing firms categorized by industry and size. The China Statistical Yearbook provides industrial value added (one of the dependent variables, mathematical notation y_{t1}) and the national invention patent application authorization number. The China Statistical Yearbook on Science and Technology provides exhaustive information on large- and medium-sized manufacturing enterprises on a number of issues, including effective invention patents (x_{t1}), R&D institution expenditures (x_{t2}), number of staff at R&D institutions (x_{t3}), number of R&D institutions (x_{t4}), domestic technology expenditures (x_{t5}), expenditure on technology absorption (x_{t6}), expenditure on the adoption of technology (x_{t7}), expenditure on technology transformation (x_{t8}), new product sales revenue (another dependent variable, mathematical notation y_{t2}), expenditure on new product development (x_{t9}), internal expenditure of R&D funds (x_{t10}), and number of full-time equivalent R&D personnel (x_{t11}).

The relationship between the variables described above is as follows. First, by definition, the secondary sector includes manufacturing, construction, mining, electricity, etc. However, in China, the World Bank WDI Database shows that the proportion of the manufacturing sector in industrial value added is typically as high as 78–80%. Therefore because the China Statistical Yearbook publishes industrial value added, but not the figures for manufacturing value added, many academic papers opt to use the industrial value added y_{t1} as a substitute for manufacturing ouput. One of the advantages of this approach is that it allows for obtaining the time-varying path of the impact of manufacturing innovation on the secondary sector. More importantly, the manufacturing industry is the top priority of China's current economic restructuring and upgrading efforts. Second, to further characterize the output of innovation in manufacturing industry, this paper uses new product sales revenue y_{t2} as another dependent variable. Finally, the independent variables in this paper are all within the system of manufacturing innovation activities. This guarantees the rationality for further

Table 1. Descriptive statistics: whole sample (period 2000-2014) and raw data.

Variables	mean	standard deviation	min	max	rang	skewness	kurtosis
GDP	310641.74	186318.48	100280.1	643974	543693.9	0.56	−1.09
x_1	85419.604	94608.932	6054	303855	297801	1.276	0.603
x_2	21137668.01	16438291.03	3075258.3	49837893.3	46762635	0.631	−1.053
x_3	958825.697	564674.083	323468.27	1805452	1481983.73	0.36	−1.488
x_4	13163.786	5677.721	6923.47	23048	16124.53	0.709	−0.788
x_5	1226424.226	584753.073	245781.3	1921047	1675265.7	−0.301	−1.494
x_6	935584.537	457952.025	176926.7	1532166	1355239.3	−0.149	−1.331
x_7	3370244.27	542682.42	2355387.1	4118747	1763359.9	−0.587	−0.825
x_8	26818426.99	7702904.703	9950797.9	36581661	26630863.1	−1.02	0.219
x_9	31185435.59	25782772.95	3791304.7	77961941.2	74170636.5	0.708	−0.964
x_{10}	27044813.06	22895096.16	3230543.3	69906623	66676079.7	0.764	−0.837
x_{11}	950607.517	571876.1816	296697	1927137.4	1630440.4	0.583	−1.123
y_1	119905.4	67169.8	39931.8	228122.9	188191.1	0.299	−1.553
y_2	502110000	390521000	76076656.7	1230000000	1150000000	0.665	−0.979

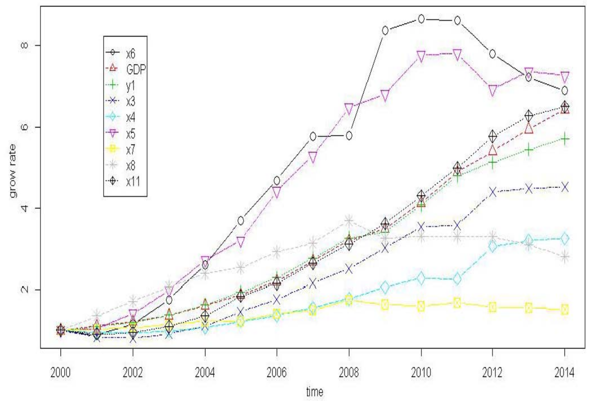

Fig. 1. The growth rate (< 9%) of GDP and variables of manufacturing enterprises (2000-2014).

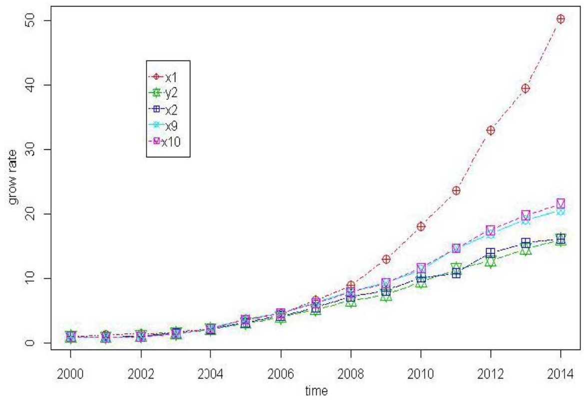

Fig. 2. The growth rate (maximum value > 9%) of variables of manufacturing enterprises (2000-2014).

research and the validity of the conclusion.

Our estimation equations are two time-varying dynamic regression models as follows:

$$y_{t1} = \sum_{i=0}^{11} x_{ti}\beta_{ti} + \beta_{t12}y_{t2} + \varepsilon_{t1}, \quad t = 1,2,\ldots,T \quad . \ (1)$$

$$y_{t2} = \sum_{i=0}^{11} x_{ti}\theta_{ti} + \varepsilon_{t2}, \quad t = 1,2,\ldots,T \quad . \ . \ . \ . \ . \ (2)$$

where $x_{t0} = 1$ for all t (and thus allows for an intercept), β_{ti} (including β_{t12}) and θ_{ti} are vectors of unknown coefficients for the i-th regressor at time t, ε_{t1} and ε_{t2} are the innovation term at time belonging respectively to Eqs. (1) and (2), the variance of the innovations is time-varying so that $\varepsilon_{t1} \sim N(0, \sigma_{t1}^2)$ and $\varepsilon_{t2} \sim N(0, \sigma_{t2}^2)$, and T is the time of final observation.

As indicated in Eqs. (1) and (2), we adopt a novel Bayesian method (Kalli and Griffin [22]) to identify the influence path of the secondary sector in the development of manufacturing enterprises, and the innovation paths of manufacturing enterprises respectively. All variables are converted to actual growth rates by dividing the index value by the value year 2000 as the base year.

3.2. Descriptive Statistical Analysis

Table 1 reports basic descriptive statistics of our estimation time series data, for the period of 2000-2014. These include gross domestic product (GDP, unit: billion yuan), and all of the innovation and R&D data on large- and medium-sized manufacturing enterprises from the Ministry of Science and Technology: x_1 (unit: one), x_2 (unit: one), x_3 (unit: person), x_4 (unit: one), x_5 (unit: ten thousand yuan), x_6 (unit: ten thousand yuan), x_7 (unit: ten thousand yuan), x_8 (unit: ten thousand yuan), x_9 (unit: ten thousand yuan), x_{10} (unit: ten thousand yuan), x_{11} (unit: persons).

Figures 1 and **2** show the actual growth rate of these variables by dividing the index value by the value in year 2000 as the base year. **Fig. 1** shows the growth rates where the maximum value $< 9\%$. **Fig. 2** shows the growth rates where the maximum value $> 9\%$.

From the descriptive statistics presented in **Table 1**, **Figs. 1** and **2**, specifically the standard deviation of all variables, we see that fluctuation is large. The average value of GDP is RMB 310,641.74 billion and the maximum value is RMB 643,974.00 billion. The difference between the maximum and the minimum is RMB

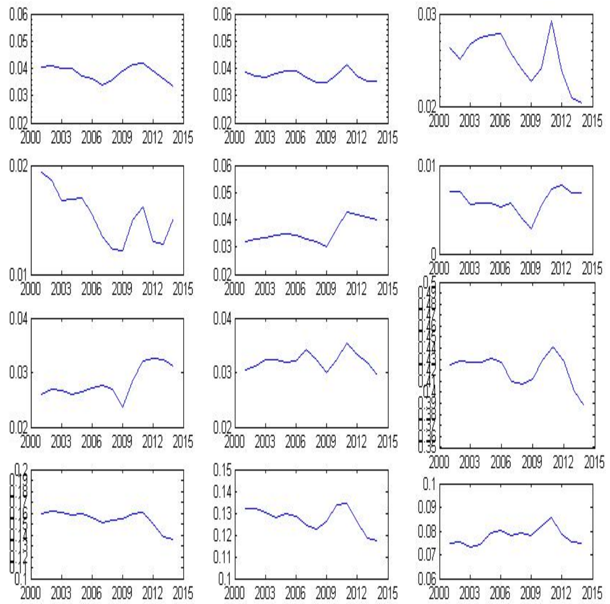

Fig. 3. Time-varying parameter β_{ti} (y_{axis}= value of β_{ti}, x_{axis}=time, $i = 1,2,\ldots,12$, $t = 2001,2002,\ldots,2014$) path based on Model 1. The parameter path is from left to right, and up to down in the panel.

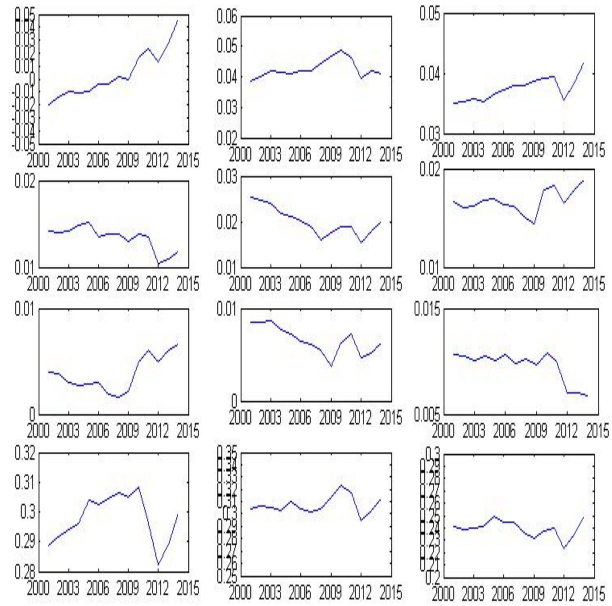

Fig. 4. Time-varying parameter θ_{ti} (y_{axis}= value of θ_{ti}, x_{axis}=time, $i = 0,1,\ldots,11$, $t = 2001,2002,\ldots,2014$) path based on Model 2. The parameter path is from left to right and up to down in the panel.

543,693.90. GDP distribution is right and flat. Compared to year 2000, the GDP growth rate continued to rise growing in pace with the industrial value added (y_1) and the full time equivalent R&D personnel (x_{11}). The average number of the large- and medium-sized manufacturing enterprises' effective invention patents (x_1) is 85,419.604. Its distribution shows a spike in the right tail, and the relative growth rate is the fastest among all indicators. The raw data for medium-sized manufacturing enterprises corresponding to y_2 and R&D institutions expenditures (x_2) show similar growth trends. The expenditure on new product development (x_9) and the internal expenditure of R&D funds (x_{10}) also show similar growth trends. The average number of staff in R&D institutions (x_3) is 958,825.697. Its growth rate has increased from 3.572% in 2011 to 4.387% in 2012, followed by a slower growth in pace with number of R&D institutions x_4. Compared to the year 2000, the growth rates of purchase of domestic technology expenditures (x_5) and expenditure on technology absorption (x_6) staggered until 2011, after which there was a clear decline. The growth rates of the expenditure on the introduction of technology (x_7) and the expenditure on technology transformation (x_8) began to fall after the financial crisis in 2008.

4. Econometric Results

This paper fits the dynamic regression model in Eqs. (1) and (2) with the Normal-Gamma AutoRegression using Bayesian MCMC methods. Therefore, the posterior is sampled integrating over $\beta_{t1},\beta_{t2},\ldots,\beta_{t12}$ and $\theta_{t1},\theta_{t2},\ldots,\theta_{t11}$, and the realizations of these parameters can be generated using standard forward-filtering backwards-sampling (Fruhwirth-Schnatter [23]) in the Gibbs sampler. The steps of the MCMC sampler follow Kalli and Griffin [22]. By iterating 12,000 times, we draw the time-varying parameter path diagrams based on Models 1 and 2 (See **Figs. 3** and **4**). From **Fig. 3**, we see the influence of the innovation path on the industrial value added in the process of transformation and upgrading of manufacturing enterprises in China. The effective patent number (x_{t1}) of manufacturing enterprises in 2008, before the secondary sector, is insufficient to boost the industry, although there is a certain increase in output value. However, the impact significantly decreased after 2011, which is quite different from its fast growth rate (see **Fig. 2**). The R&D institutions expenditures (x_{t2}) for the entire industrial output value is still relatively weak. The impact of the staff of R&D institutions (x_{t3}) on the entire industrial output value in 2006 and two 2011 time points significantly decreased. The number of R&D institutions (x_{t4}) is not more favorable (i.e., the impact on the industrial output value shows a declining trend year after year, despite the improvement from 2009 to 2011). Following China's investment of 4 trillion yuan, the impact of the following variables on the industrial value added in 2009 dropped to their lowest points: purchase of domestic technology expenditures (x_{t5}), expenditure on technology absorption (x_{t6}), expenditure on the adoption of technology (x_{t7}), expenditure on technology transformation (x_{t8}), expenditure on new product development (x_{t9}), and internal expenditure of R&D funds (x_{t10}). The results were significant, but after 2011, the results began to decline. The contribution of new product sales revenue (y_{t2}) to the secondary sector began to decline in 2011, but by 2013, it began to pick up. The full time equivalent number of R&D personnel (x_{t11}) on the industrial value added has a positive impact, but in 2011 there was a new turning point.

From **Fig. 4**, we see the influence of the innovation path on new product sales revenue (y_{t2}) in the process of transformation and upgrading of manufacturing enterprises in China. On average, new product sales revenue (y_{t2}) increased on a year-by-year basis. The number of effective invention patents (x_{t1}) on new product sales revenue (y_{t2}) in 2011 appears to have peaked, followed by a significant decline in the effect. The R&D institutions expenditures (x_{t2}) and the expenditure on new product development (x_{t9}) appear to have had a low effect in 2012. The staff of R&D institutions (x_{t3}), number of R&D institutions (x_{t4}), expenditure on the adoption of technology (x_{t7}), and expenditure on technology transformation (x_{t8}) have negative impacts on the new product sales revenue (y_{t2}). The contribution of the purchase of domestic technology expenditures (x_{t5}) and the expenditure on technology absorption (x_{t6}) to the new product sales revenue (y_{t2}) rose significantly and positive effects after 2009. The internal expenditure of R&D funds (x_{t10}) and R&D equivalent full time personnel (x_{t11}) on new product development decreased significantly over the 2009-2012 year, but rose significantly after 2012.

In summary, our estimation results provide evidence on our Hypotheses. In particular, our results show that the transformation and upgrading of China's manufacturing industry is still far from advanced; further, R&D institutions require improvements and mobilization of enthusiasm for innovation in R&D staff as well as streamlining. Finally, our findings also point to the need for increased internal R&D investment funds, while in short term it also calls for continued efforts to improve product innovation capacity through technology generation, giving further support to Hypothese 3 and 4.

5. Conclusions

In this paper, we analyzed the impact of the innovation path on the industrial value added in the process of transformation and upgrading of manufacturing enterprises, and the innovation path on new product sales revenue in the process of transformation and upgrading of manufacturing enterprises in China. Our empirical approach is based on Kalli and Griffin [22], and we use a MCMC Bayesian method for dynamic regression models where both the values of the regression coefficients and the importance of the variables are allowed to change over time.

We used a time series data set for Chinese manufacturing firms provided by the China Statistical Yearbook and China Statistical Yearbook on Science and Technology for the period 2000-2014, which is representative of China's entire manufacturing sector comprising large- and medium-sized firms. Our measure of the economic indicators of growth rate uses 2000 as the base period.

Our results indicate that China's relevant research departments within firms need to improve the efficiency of R&D institutions and to mobilize the enthusiasm of full-time R&D personnel, to provide a solid foundation for innovation and transformation, and upgrading of the manufacturing industry, as well as the efficiency of R&D investments and new product R&D investment. In the current context, it is necessary to continue to support the adoption of technology.

The main contribution of the paper is providing evidence that some manufacturing enterprises' R&D institutions are too complex and inefficient, with problems in the use of funds. Enthusiasm in R&D personnel may also not be high. Lack of innovative capacity of enterprises leads to a situation where money is wasted. The new technology generation is necessary, and enterprises need to upgrade in a timely manner. Our results suggest some implications for innovation policies. First, government departments should implement differentiated policies for manufacturing enterprises in R&D. For example, government departments should increase policy support for the strategic development of key industries. Enterprises that do not have development potential or enterprises with long-term losses should be laid off or even eliminated. Second, it should give full prominence to the leading role of industry funds. Industrial funds could play the role of financial leverage to attract social capital to participate in investments with development potential for small and micro industrial enterprises and emerging industries. Finally, China should improve the financing guarantee system of manufacturing industry. There is a need for the acceleration of the government and market functions to guarantee finance, effectively playing the role of a risk compensation fund in leveraging its role to support industrial enterprises in financing.

6. Strategy Moving Forward

Upgrading of traditional industries, in addition to technological innovation and product innovation, involves transformation of the mode of production. To build a new manufacturing mode, industries must be transformed to flexible, intelligent, and meticulous. This is undoubtedly the essence of industrial transformation and upgrading, but is also becoming the development goal that most domestic enterprises are pursuing.

It is worth noting that in China's industrial revolution, traditional and emerging industries are blending in a complementary manner. The technology industry, equipment manufacturing industry, as well as the rapid development of information technology and application, is driving the transformation of traditional industries to create a model to improve its competitiveness.

However, there are some issues still pending for implementing China's industrial transformation and upgrading in enterprises. Adhering to the artisan spirit, firm independent innovation, and core technology promote Chinese manufacturing to build international brands. To this end, we propose several strategies as follows: design services to enhance action, promote innovation and design development and promotion of customized services; implement actions to improve manufacturing efficiency; optimize the supply chain management; promote the development of networked collaborative manufacturing services and outsourcing support services; implement customer value promotion action; implement product life cycle management; provide system solutions and innovative value-added information services; implement actions to innovate service models; develop financial support services; and grasp new trends in smart services.

With regards to the implementation of innovation driven development strategies, the State Council issued the China manufacturing 2025 plan in May 2015 (Chunmei, Xiaodong, and Tao [24]), which encourages the implementation of the innovative manufacturing power strategy, seizes the rare present opportunity, and exerts intellectual superiority. The objective is to realize the transformation from made-in-China, speed-in-China, and quality in China.

An optimistic view is that China is a big manufacturing country, but could also become a super internet power. Data shows that Chinese manufacturing value added was up 6.8% in 2016, including the global manufacturing output accounted for more than 19.8%, and China is the world's largest exporter for 6 consecutive years. At the same time, the size of China's internet users reached 688 million, internet penetration rate rose to 50.3%, and online retail market transactions amounted to 38,285 yuan, ranking first in the world. In addition, in automotive industry, the sale of internet-enabled cars (Chen [25]) and smart cars are booming. In this case, the integration of the manufacturing industry and the internet, would create large aggregation and multiplier effects.

However, the fusion of the manufacturing and the internet is still in its infancy. From the domestically scale, more manufacturing and the internet mean the realization of the integration of manufacturing units or production lines. It is extremely rare to achieve a workshop or factory-wide intelligence effect. Many manufacturers choose to build an internet platform and cross-border integration of the manufacturing industry and internet companies have not yet become mainstream. Accordingly the integration of the manufacturing industry and the internet is also a promising opportunity in China.

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