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Research on the "Internet Plus" Economic Model and Evaluation System

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Abstract: Integration of the Internet in various industries has become an inevitable trend. The Chinese government has thus promoted positive strategic innovation through the rapid global implementation of the "Internet Plus" strategy. This study analyzes the transmission mechanism of "Internet Plus" for economic growth and structural transformation through the construction of a theoretical model. Based on the current progress of "Internet Plus" in China, this study aims to list and classify the evaluation index for "Internet Plus" to formulate a valid evaluation system. The proposed system can be applied to assess the efficiency of resource inputs, the level of application integration, and the extent of collaborative innovation. Furthermore, the proposed study can help evaluate, and thereby demonstrate, trends in the development of "Internet Plus" manufacturing intelligence.

Keywords: Internet Plus; economic model; evaluation system

1 Introduction

As was highlighted by Jean Tirole, a Nobel laureate in economics, in his 2017 book, the digital economy is full of opportunities, and every economic sector is involved in it [1]. Internet technology research and its ubiquitous popularization have accelerated the speed of information dissemination and promoted the proliferation of new technologies, new models, and new forms. Internet technology has integrated with other industries in the economy, changing the rules of operation for the entire economic system [2]. Developed countries, in particular the United States, Germany, the United Kingdom, and Japan, have pursued one innovation strategy after another and have successively formulated related "Internet Plus" strategies, with a view to consolidating their leading edge in technology and industry and actively controlling future industrial development [3]. China is at a critical stage in transforming from high-speed economic growth to high-quality development. In particular, the Chinese manufacturing industry is in the midst of a historic period of shifting from "Made in China" to "Created in China," and the Chinese government is actively pressing ahead with strategic innovation. In 2015, China introduced the "Internet Plus" Action Plan and "Made in China 2025." In 2016, it promoted the integrated development of "Made in China 2025" and the "Internet Plus" Action Plan, which makes the integrated development of "Internet Plus" in various industries an important direction for China's development. This paper summarizes the challenges facing China's development of "Internet Plus" by building a theoretical model involving the impacts of "Internet Plus" on China's economy; it probes into the establishment of an "Internet Plus" evaluation system and uses "Internet Plus" intelligent manufacturing as an example to test the practical effects of the evaluation system.

2 Economic theory model of "Internet Plus"

"Internet Plus" has triggered the rapid migration of China's industry to a high-end value chain, bringing about tremendous changes to the national economy [4]. Under the premise of

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giving comprehensive consideration to the Hicks neutral technological progress and Solow biased technological progress that are triggered by “Internet Plus,” we analyze the impacts that the “Internet Plus” has on China’s economic change by constructing a theoretical model concerning the transmission mechanism of “Internet Plus” to economic growth and structural transformation.

2.1 Model

In the event that uncertainty is excluded and time is continuous, the utility function of an individual in the economy can take the form of $\int_0^\infty e^{-\rho t}\mu(c_t)\mathrm{d}t$. If the individual’s instantaneous utility function is assumed to be $\ln c_t$, the individual’s utility function for their lifetime and the output of the entire economy can be, respectively, expressed as:

$$\int_0^\infty e^{-\rho t}\ln c_t \mathrm{d}t \tag{1}$$

$$Y_t = A_t J_t^\alpha L_t^{1-\alpha} \tag{2}$$

In formulas (1) and (2) , t is time, $\rho \in (0,1)$ is the discount rate of the individual’s utility, c_t is the individual’s instantaneous consumption, Y_t is the total economic output, A_t is “Internet Plus”-triggered Hicks neutral technological progress, J_t is the capital stock, L_t is the labor inputs, and α is the output elasticity of capital, assuming that the production function is homogeneous. For $x_t = X_t / L_t$, analysis is conducted using simplified variables from the per capital perspective. The production function can be expressed as:

$$y_t = A_t j_t^\alpha \tag{3}$$

Assuming that the final product produced at each time point is used for consumption, investment, and R&D or “Internet Plus” inputs, resource constraints can be expressed as:

$$c_t + i_t + r_t = A_t j_t^\alpha \tag{4}$$

In formula (4), i_t is investment and r_t is R&D or “Internet Plus” inputs. Meanwhile, consideration is given to the following assumptions: (1) R&D or “Internet Plus” inputs enter the capital goods production sector in the same way, (2) R&D or “Internet Plus” inputs will improve the quality of new capital goods and their efficiency after being put into production, (3) new and old capital goods produced have the same quality and efficiency without considering learning by doing, or in the absence of R&D or “Internet Plus” inputs; and (4) a corresponding increase in the amount of capital goods produced due to an increase in investment equals the increase of its efficiency.[1] Based on the four assumptions above, the production function of new capital goods can be expressed as:

$$\Phi\,(i_t, v_t) = B i_t^{\theta\eta} v_t^{\theta(1-\eta)} \tag{5}$$

In formula (5), v_t is the stock of R&D and “Internet Plus” inputs.[2] Under the premise that R&D and “Internet Plus” inputs are not depreciated, the relationship between its input stock v_t and input flow r_t as well as the capital goods accumulation equation can be expressed respectively as:[3]

$$\dot{v}_t = r_t \tag{6}$$

$$\dot{j}_{t+1} = \Phi\,(i_t, v_t) - \delta_d j_t \tag{7}$$

In formula (7), δ_d is the physical depreciation rate. Up to this point, the basic description of the entire model has been completed, and the model includes R&D and “Internet Plus” inputs, capital goods production, final product production, final consumption, investment, and other links. The differences between our model and the traditional neoclassical economic growth model are mainly reflected in: (1) this model distinguishes capital goods production and final product production; (2) this model also considers the possibility of the coexistence of two technological progresses – neutral technological progress and capital biased technological progress (assuming that K_t represents the capital stock under neoclassical economic growth, the relationship between it and the capital stock in this model can be expressed as $J_t = Q_t K_t$); and (3) this model assumes that Hicks neutral technological progress is exogenous, while capital-biased technological progress is endogenous and determined jointly by R&D and the input spent in purchasing foreign advanced equipment.

2.2 The optimal path and the solution to the model

The Bellman equation for dynamic programming optimally chosen by social planners is[4]

$$V\left(j_t, v_t\right) = \max_{(i_t, r_t)} \left\{\ln c_t + \rho V\left(j_{t+1}, v_{t+1}\right)\right\} \tag{8}$$

The constraint of the equation is

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1 Denison (1964) holds the same view: quantity and efficiency are equivalent, that is, “better” means “more”[5].

2 Φ_i, $\Phi_v > 0$, Φ_{ii}, $\Phi_{vv} < 0$, $B > 0$, $\theta > 0$, $0 < \eta < 1$. $\theta\eta$ is the substitution elasticity of inputs in investment and R&D or inputs spent in purchasing foreign equipment. In a special case, ($\eta = 1$) and $\Phi(i_t, v_t) = B i_t^\theta v_t$. In such case, the production function is similar to the learning-by-doing model. Intuitively, the growth in R&D inputs or inputs spent in purchasing foreign equipment will become the source of economic growth.

3 The above functions indicates that one unit of investment product and one unit of R&D input that are measured with the consumer goods unit will form one unit of a new investment product.

4 Assuming that the market is completely competitive, the results of the social planner’s optimal choice and competitive equilibrium are the same.

$$
\begin{aligned}
&c_t + i_t + r_t \leqslant y_t = A_t j_t^{\alpha} \\
&j_{t+1} = (1-\delta_d) j_t + \Phi(i_t, v_t) \qquad (9) \\
&v_{t+1} = v_t + r_t
\end{aligned}
$$

The Euler equations for capital accumulation, R&D and "Internet Plus" inputs are[1]

$$Q_t/Q_{t-1} = \{\rho/(c_t/c_{t-1})\}\{(\alpha + r)(y_t/j_t)Q_t + (1-\delta_d)\} \qquad (10)$$

$$1/(R_t/Q_t + 1) = \rho/(c_t/c_{t-1}) \qquad (11)$$

According to $Q_t = \theta\eta B i_t^{\theta\eta-1} v_t^{\theta(1-\eta)}$, we have

$$Q_t/Q_{t-1} = (i_t/i_{t-1})^{\theta\eta-1}(v_t/v_{t-1})^{\theta(1-\eta)} \qquad (12)$$

Considering the situation on a balanced growth path, output, consumption, investment, R&D inputs, and capital will grow at a constant rate. According to $c_t + i_t + r_t = y_t$, it is assumed that output, consumption, investment, and R&D inputs will grow at the same rate, g. According to formula (10), the growth rate of capital is $g_j = g^{\theta} = g(Q_t/Q_{t-1})$. According to $g_Q = Q_t/Q_{t-1}$, $g_A = A_t/A_{t-1}$, we have

$$g = g_A^{1/(1-\alpha)} g_Q^{\alpha/(1-\alpha)\,2} \qquad (13)$$

2.3 Conclusion of theoretical analysis

According to formula (13), the impacts of "Internet Plus" on the entire economy can be divided into three parts: (1) On the balanced growth path, g_Q indicates that the traditional industry is impacted by "Internet Plus." The value labeling built by "Internet Plus" has broken the original "logic" of the industrial era [6]: the traditional pattern of economic growth is being seriously challenged, and the economic pattern in which Internet technology serves as the core growth driver is replacing the original pattern. (2) g_A means that "Internet Plus" widely affects various fields of the national economy in the way of Hicks neutral technological progress. "Internet Plus" has become a value-creating connector [7], and the new types of business, new models, and new markets that are formed by "Internet Plus" have become innovation-driven, optimized resources, and improved efficiency. (3) The substitution relationship between g_A and g_Q indicates that the future pattern of economic growth is a rebirth of the traditional types of businesses, co-existing and developing with the new types of businesses shaped by "Internet Plus." Shaped by traditional types of businesses and guided by new ones, the global economic development pattern is accelerating into being, the network innovation system is increasingly perfect [8], and the "Internet Plus" economic ecosystem becomes gradually prominent.

3 Establishing the evaluation system for "Internet Plus"

"Internet Plus" is an important approach to forming a new driver of economic development and to upgrading the quality and efficiency of China's economy. With the increasing number of "Internet Plus" objects and the "Plus" going deeper by degrees, the Internet is no longer an information network in a traditional sense or a tool in general [9]; instead, it has become a fusion body, integrating human social space, virtual cyberspace, and physical space. Evaluating the effectiveness of "Internet Plus" scientifically and objectively will help promote the application of the Internet to enterprises in various sectors, achieve optimal resource allocation and value creation through the use of big data [10], and form ecosystems within and across industries. Ultimately, it will help form a new type of business, which will generate ubiquitous interconnections across various fields and will be characterized by data-driven operations, shared services, cross-border integration, indigenous wisdom, and mass innovation.

3.1 "Internet Plus" evaluation thought process

The above theoretical model shows that the development effectiveness of "Internet Plus" is influenced by capital accumulation and R&D and "Internet Plus" inputs. The effectiveness is also related to the fact that "Internet Plus" inputs improve the quality of new capital goods and efficiency after the Internet is put into production, which is ultimately manifested in economic utility and economic output. On such a basis, this "Internet Plus" evaluation system includes two parts: level and capability evaluation as well as effectiveness and benefit evaluation. The former is mainly targeted at the basic capabilities as well as integrated application level of "Internet Plus," while the latter focuses on competitiveness and the economic and social benefits of "Internet Plus."

3.2 "Internet Plus" evaluation framework

The "Internet Plus" evaluation index system is constructed in three dimensions, namely input, process, and output. It comprises four major primary indexes (e.g., resource input capacity, integrated application level, collaborative innovation capability, and economic and social benefits) and several secondary ones. The "Internet Plus" evaluation index system is shown in Fig. 1.

(1) The resource input capacity index, which focuses on evaluating the basic conditions for enterprises to implement "Internet

[1] The objective function is concave, the constraint is linear, and the interior optimal solution is given by the first-order condition.

[2] If and only if $\theta = 1/(\alpha + r)$, the economy will converge to a balanced path; when $\theta < 1/(\alpha + r)$, the economy will converge to a static equilibrium; when $\theta > 1/(\alpha + r)$, the economy will not converge to any balanced growth path. This model gives consideration to the situation of the balanced path, which is, $\theta = 1/(\alpha + r)$.

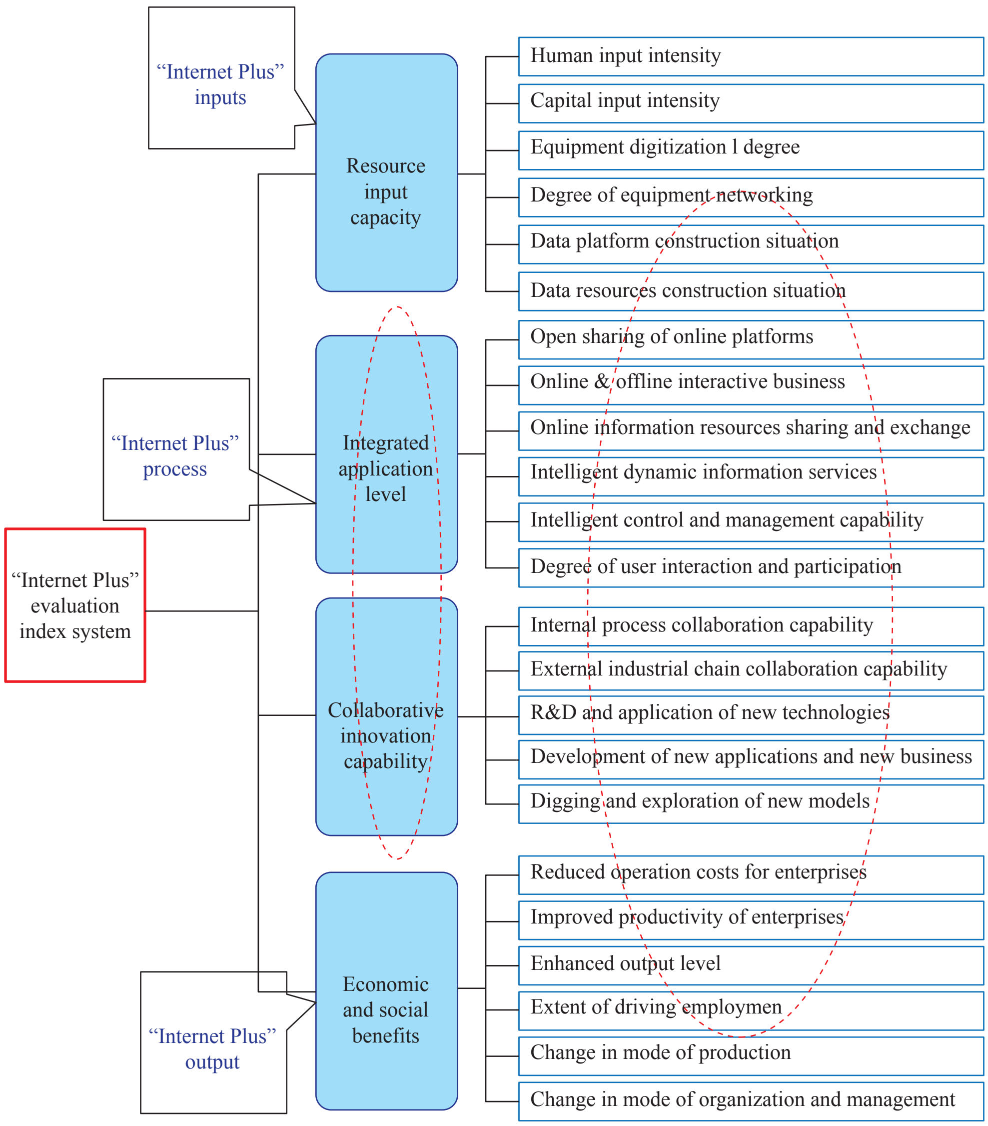

Fig. 1. The "Internet Plus" evaluation index system.

Plus," primarily measures the level and capability of enterprises, including Internet-related inputs, facilities, security guarantees, and information applications. For the resource input capacity index, secondary indexes can be constructed in four dimensions: factor inputs, platform construction, data resources, and security protection. More specifically, these include human inputs, capital inputs, production equipment inputs, data resource bases and data chain construction, and security of both cyberspace and physical space.

(2) The integrated application level index, with a focus on assessing business collaboration and operation activities conducted through the use of the Internet within and outside the enterprises and in different aspects, primarily measures the level and ability of the enterprises in carrying out internal and external business collaboration and user participation by means of the Internet. For the integrated application level index, secondary indexes can be established in three dimensions: business model innovation, intelligent application, and user participation. More specifically, these include the open sharing of online platforms, level of online and offline integration, intelligent dynamic information services, intelligent control and management (intelligent production, intelligent design, intelligent products, intelligent operation, intelligent decision-making, etc.), and degree of user interaction and participation.

For the collaborative innovation capability index, secondary indexes can be built in three dimensions: Internet application in facilities and products, external resource utilization, and industrial chain integration. More specifically, these include networking of equipment and products, internal process collaboration, industry chain collaboration, external resources participating in innovation, and flow of data resources.

(3) The index of economic and social benefits, which assesses how enterprises enhance their competitiveness by relying on the Internet and the changes in external economic and social bene-

fits, primarily measures the impacts that the implementation of "Internet Plus" has on innovation, efficiency, performance, and employment. Such an index can construct its secondary indexes in four dimensions: policy environment, competitiveness, economic benefit, and social value. More specifically, these include enterprise strategic positioning, enterprise productivity, driving employment, organization and management reform, and economic output.

4 Initial evaluation by using "Internet Plus" intelligent manufacturing as an example

We designed an overall evaluation index using four aspects: resource input capacity, integrated application level, collaborative innovation capacity, and economic and social benefits with a view to a more in-depth and quantitative analysis of the current development level and trends in "Internet Plus" intelligent manufacturing as pursued by the manufacturing industry. This analysis can, thereby, help in planning future development goals. Next, we provide a preliminary estimate and analysis of the important aspects of the index system.

4.1 Evaluation of "Internet Plus" intelligent manufacturing development

Intelligent manufacturing requires the in-depth application of intelligent technology, products, and services such as automatic controls, information, communication, detection, and remote sensing, in production and management activities. In addition, as is required by intelligent manufacturing, enterprises can realize self-perception, self-adaptation, self-adjustment, and self-determination in production and management activities with the guarantee of advanced intelligent equipment and technology. For enterprises to promote intelligent manufacturing systematically and effectively, a higher level of numerical equipment control and a basic realization of comprehensive integration are the primary conditions. At present, 5.1% of enterprises in China have the initial competence to explore intelligent manufacturing, representing an increase of 0.7% from 2015. This means that the intelligent manufacturing base of Chinese enterprises is weak and that an escalated effort is needed to rapidly improve the level of integration between industrialization and information applications in Chinese enterprises in the future, continuously consolidate the foundation of intelligent manufacturing, and effectively step up the development of intelligent manufacturing.

4.1.1 Resource input capacity

In terms of industrial software penetration, the penetration rate of production control software is significantly lower than that of business management and product development software. The higher the requirement for personalized and customized software, the lower its penetration rate is. For example, the penetration rate of SCADA, CAM, MES and other production control software is merely 15%. In terms of platform construction, the utilization rate of enterprise cloud platforms is at a low level. Only 33.5% of enterprises had adopted cloud services by 2016. The penetration rate of "innovation and entrepreneurship" Internet platforms in the manufacturing industry is 47.0%, with an increase of 2.4% over 2015. This rising ratio also indicates increasing vitality in "innovation and entrepreneurship" on the part of Chinese manufacturing enterprises. As far as data resources are concerned, Chinese enterprises are seeing a steady annual increase in data applications for the entire process year by year and further penetration into R&D, design, and manufacturing links, and the proportion of enterprises fulfilling automatic data collection and uploading during R&D, design, and production management has increased significantly. The practice of deeply extracting data value and applying it in intelligent decision-making by using advanced data analysis tools and models has only just begun. There are only 16.1% of companies capable of comprehensive decision-making optimization, early warning, and forecasting by collecting internal and external information online. In the business scope of automatically collecting information and conducting comprehensive analyses based on an intelligent-knowledge model, the coverage for serving the sites and competitive intelligence is only 3.1% and 10.0%, respectively.

4.1.2 Integrated application level

In light of the application of the Internet in facilities and products, the digitization rate of production equipment of industrial enterprises in China was 44.1% in 2016, and the networking rate of digital production equipment was 38.2%, increasing by 1.2 and 0.9 percentage points over 2015, respectively; and the development of automatic controls and sensing systems has made certain progress. In terms of intelligent application, it is affected by insufficient effective integration levels in all aspects of the supply chain, so basic conditions are still incomplete for the promotion and spread of precise procurement, customized production, and accurate distribution in Chinese enterprises. In 2016, only 27.9% of enterprises were able to achieve effective integration of raw material inventory, production management, finished goods inventory and sales management. Among others, 17.5% of the enterprises were able to respond to customer needs rapidly and accurately and to carry out customized production. Only 18.3% of enterprises were capable of fulfilling the effective integration of production management, finished goods inventory, sales management, and distribution management, 14.6% of which were able to achieve accurate on-demand delivery in a timely manner. The digital application level in the four areas of production management and control (the bottom equipment, process control, manufacturing execution, and production management levels) for Chinese enterprises is "high at both ends and low in the middle" overall. The digital penetration rate for the process control and manufacturing execution levels, was merely around 30%, and has become an important breakthrough point for achieving production control.

4.1.3 Collaborative innovation capability index

With regard to external resource utilization and industrial chain integration, collaborative models such as collaborative design and manufacturing and industrial chain resource sharing, demand high levels of informatization and networking and involve the entire process of basic enterprise management and production (services). Therefore, the overall development is at a low level. At present, about 30% of Chinese enterprises can realize networked product collaborative design and manufacturing between regions, and 26% can achieve these among domestic enterprises. In terms of information interaction and sharing, less than 30% of enterprises have constructed an industrial chain or adopted unified information standards and norms, and only 22.4% have realized the sharing and real-time interaction of industrial chain related information between enterprises. Currently, the penetration rate of e-commerce in China's industrial enterprises is 54.0%, the online procurement rate for enterprises averages only 25.5%, and the online sales rate is only 22.0%. Market and business collaboration must be urgently improved for industrial enterprises in terms of both depth of application and coverage, and especially in terms of the penetration of the key links for online transactions. When it comes to model innovation, the proportion of enterprises that carry out online remote services was 21.0% in 2016, an increase of close to 2% over 2015; among them, the proportion of those carrying out remote monitoring and online operation and maintenance was 25.5% and 7.3%, respectively. Although only 5.4% of enterprises achieved personalized customization, it represents an increase of 1.2% compared with 2015, with a growth rate of over 28%. The above data shows that as the integration of the Internet in manufacturing enterprises deepens, leading domestic enterprises engaged in various industries and fields have carried out positive and beneficial explorations of service model innovation.

4.2 Analysis of the trend of "Internet Plus" intelligent manufacturing

According to the growth rate of intelligent-manufacturing-ready enterprises in 2016, it is estimated that by the end of 2018, the proportion of such enterprises in China will reach above 8.5%. "Innovation and entrepreneurship" Internet platforms in the manufacturing industry have become a new driver promoting the transformation and upgrading of the manufacturing industry; the penetration rate of "innovation and entrepreneurship" Internet platforms in key and backbone enterprises in the manufacturing industry is expected to reach 80%. Breakthroughs will be made in R&D and industrialization for automatic control and sensing technology, and the supply capacity of industrial hardware and software will steadily improve. The penetration rate of industrial cloud and intelligent service platforms will exceed 50%, gradually becoming key application infrastructure of intelligent manufacturing. The mode of production will significantly improve in delicacy, flexibility, and intelligence, and the numerical control application rate for key processes will reach 50%. Network collaborative manufacturing, personalized customization, and service-oriented manufacturing will become important models that lead high-end manufacturing. New modes of service, such as industrial e-commerce, will flourish, and major breakthroughs will be made in key technologies and equipment related to intelligent manufacturing, including complete sets of intelligent manufacturing equipment, R&D, and the industrialization of intelligent products. Significant headway will be made in the digitization, networking, and intelligentization of the manufacturing industry, which will become the core driving force for consolidating the status of China as a manufacturing power and accelerating its to move towards becoming a strong manufacturing nation.

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