Economic Impact of Information Industry Development and Investment Strategy for Information Industry

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ABSTRACT

The information industry leads the digital revolution and innovation. With regards to what economic impact the development of the industry will bring about, there has been minimal focus from literature. This paper fills the knowledge gap by using a dynamic computable general equilibrium model. The results show the development will rapidly promote economic development and social welfare, promote the reduction of commodity prices and the rise of output by providing higher social productivity. Finance, public service, and some traditional industry (such as electricity) will benefit more when the information industry develops rapidly. At present, the industry development of the information industry is more directed at the service industry and final consumption. This paper implies the information industry can strengthen R&D investment towards supporting finance, public services and traditional industries, such as industrial control embedded software products, cloud computing technology, and emergency communication for traditional industries to increase the income.

KEYWORDS

Computable General Equilibrium Model, Development, Economic, Impact, Information Industry, Investment Strategy

1. INTRODUCTION

Enterprise decision-making comes from industry development, and industry development also depends on enterprise decision-making (Ferreira et al. 2016; Gonçalves et al. 2019). The arrival of the era of big data has given research value to digital and information. Production and service models based on information and network are expanding the scope and form of creating and utilizing the information by human, promoting the traditional industries switch towards intelligence, informationization and digitization (Angelovska 2016).

The development of today's society is increasingly inseparable from digital technology and information services (Gallipoli and Makridis 2018). Automation and intelligence gradually penetrated from the tertiary industry to the secondary industry and the primary industry (Zhang et al. 2017). Information technologies have been used in various industries, such as the green information technologies (Przychodzen, Gómez-Bezares, and Przychodzen 2018), the applying in tourism

management (Navío-Marco, Ruiz-Gómez, and Sevilla-Sevilla 2018), applying in food industry (Schneider et al. 2019), applying in medicine (Asan et al. 2018). The rapid development of digital technology has also brought about some problems (Fixson and Marion 2012), such as the dependence of young people on digital products (Wang, Sigerson, and Cheng 2019). However, it is undeniable that enterprises rely more and more on digital to improve the core competitiveness. Digitalization also brings innovation, efficiency and convenience to society (Chen et al. 2018).

Taking China's software industry as an example, it is indicated that number of enterprises in software industry was increasing from 18.1 thousand in 2009 to 39.4 thousand in August 2019, and average annual growth rate is 8.1%. However, the total profit of the industry increased from 33.2 billion CNY in 2009 to 4835.2 billion CNY in 2018, accounting for 5.4% of 2018 GDP in China. The annual growth rate of the profit is 73.9%. Profit growth is almost exponential (see in Appendix A). The number of Internet users was 384 million in December 2009 and was 854.49 million in June 2019, however, the transaction volume of online shopping increased from 250.0 billion CNY in 2009 to 9006.5 billion CNY in 2018. The transaction volume of online shopping increase 48.9% per year (see in Appendix A). No matter from the enterprise side or from the residents side, the development of the information industry is exponential in recent years.

Industrial development has experienced through three eras, the first is the era of the steam engine, the second is the era of electrification, the third is the era of information. Now Industry 4.0 is coming, which is the era of using digital technology to promote industrial transformation, that is, the era of intelligence (Lasi et al. 2014; Liao et al. 2017). Information innovation and management could help traditional industries, such as textile, automotive industry (Dwaikat et al. 2018; Chiplunkar, Chattopadhyay, and Deshmukh 2001). Therefore, the economic impact of the development of information industries is worth studying. This paper seeks to address these questions: what is the impact of the accelerated development of the information industry on GDP? What are the spillover effects on other industries? Which industries will benefit more?

In China, as labor costs continue to rise, the real wages of Chinese manufacturing workers have nearly doubled in 2015 compared with 2006, low-cost labor advantage is a thing of the past. Therefore, China's manufacturing enterprises are striving to achieve transformation and upgrading: to improve the use of automation equipment, and to control operating costs and management costs through enterprise information management, to transform production and processing models (from cheap-labor-based production model to high value-added production and service models with independent intellectual property rights. The development of the information industry will undoubtedly bring great spillover effects and promote the development of other enterprises and the entire economy. Thus, this paper will aim to the economic impact of information industry development by applying a Computable General Equilibrium (CGE) model, hoping to bring some implications to policymakers.

The basic structure of this paper is organized as; introduction and literature review of digital technology and digital industry development are presented in section 1 and section 2. The methodology is briefly introduced in section 3. The scenario design is described in section 0. The simulation results and discussions are provided in section 5. The conclusions and implications are proposed in section 6.

2. LITERATURE REVIEW

The impact of digital design and information technology (IT) is a hot topic (Farrell 2017; Yin et al. 2019). Many scholars have researched on this field.

Some of them focus on the impact of information industries at enterprise level. Marion, Meyer, and Barczak (2015) explored the impact of them on the development of modular product architectures and finally found an insignificant relationship between digital design tool usage and modular product architecture or overall project outcomes. Mauerhoefer, Strese, and Brettel (2017) studied the impact of information technology on new product development performance. Lin, Chen, and Hung (2019)

evaluated the business value of information technology. Pergelova et al. (2019) examined how digital technologies affect the international expansion of female-led small and medium-sized enterprises.

Most of the above literature is enterprise-based study, which means they are studying issues at the enterprise level and providing a business-level perspective. However, some scholars have focused on the impact on industry level or a region. Such as, Kolloch and Dellermann (2018) explored digital innovation in the energy industry, so did Watson, Boudreau, and Chen (2010). For a traditional industry like this, the process of digitization will be relatively slow, but still necessary. Choy et al. (2014) examined the current state of the use of information technology and its impact on logistics service performance through a survey. Geiß, Jackob, and Quiring (2013) studied on how information and communication technology journalists conceptualize their influence on the audience and the industry. Qu, Pinsoneault, and Oh (2011) analyzed the influence of industry characteristics on information technology outsourcing and proposed that industry concentration is negatively related to information technology outsourcing. Ho and Mallick (2010) analyze the impacts of investment in information technologies (IT) on the banking sector. The results suggest that (at individual firm levels) the bank profits can decline due to adoption and diffusion of information technology investment, reflecting negative network competition effects in this industry.

However, few researches focused on the impact of information industries on the economy. This paper will fill the knowledge gap to answer the question of what impact will the development of the information industry have on GDP, household consumption, and other industries? It will be an interesting topic and can help us have a better understanding of the positioning of the information industry in the whole society.

3. METHODOLOGY AND DATA SOURCES

3.1. CGE Model

In order to complete such a simulation analysis, CGE model is utilized in this paper. We could easily explore the impact of IT development, as the model is widely used for analysis of macro impact (Pauliuk et al. 2017; Acemoglu, Ozdaglar, and Tahbaz-Salehi 2017; Jafari and Britz 2018). Different from input-output analyses (Apesteguia and Ballester 2015), game theory analyses (Kajackaite and Gneezy 2017) and statistical or econometric analysis (Zhu et al. 2019), CGE model can analyze the impact of target issue on the whole society better. As the model is a social scenario analysis model, we can analyze the information industry as a part of the whole society. However, CGE model itself is not suitable for prediction, but it has a strong analysis ability for the impact mechanism. We summarized 3 characteristics of CGE model (Massiani 2018; Bjerkholt, Førsund, and Holmøy 2016):

1. The supply and demand function clearly reflect the behavior of producers pursuing profit maximization and consumers pursuing maximization of utility.
2. The quantity and relative price are both endogenous in the model, and the resource allocation method is determined by the general equilibrium model structure with Walras's law.
3. The focus of this model is on simulating the physical aspect of the economic entity. The resources of the economy in the model have been fully utilized.

CGE model in this paper consists of four blocks: production block, income-expenditure block, trade block, and macroscopic-closure & market-clearing block (B. Lin and Jia 2019). As CGE model itself is a static model, a recursive method for dynamic is applied in this paper. The framework of this paper is illustrated in Figure 1. The solid line represents commodity flow in the process of production and trade. The dotted line represents the cash flow between household, government, enterprises and the rest of the world.

Figure 1. The framework of CGE model in this paper
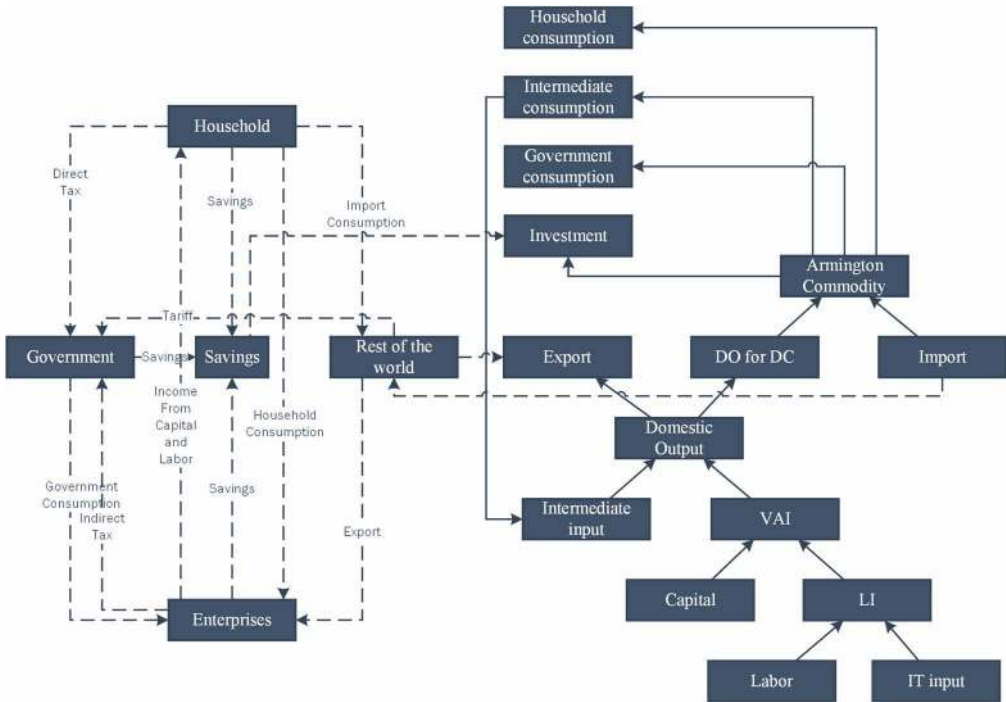
3.1.1. Production Block

The basic structure of the production block is illustrated in Figure 2. This paper introduces Constant Elasticity of Substitution (CES) production function and Leontief production function to describe the production process aof the sectors. As the information industry is the core of this paper, we extract intermediate input of information industry from the aggregate intermediate input to the factor input. Considering the input in information technology will replace human capital to a certain extent, IT input and labor input constitute Labor-IT (LI) input by CES function. On the upper level of composition, Value-Added-IT input is a CES function consists of Capital input and LI input following a CES function. Domestic output consists of intermediate input and VAI input following a Leontief function. The elasticity of the two CES functions are according to (Lou 2015; B. Lin and Jia 2018).

Note that each industry in CGE model has the same framework of production technology by several CES and Leontief production functions. However, as the production technology is different in these industries, the difference lies in scale coefficient and share coefficient. Moreover, information industry is one of these industries and the industry also need the intermediate input of information industry itself.

3.1.2. Trade Block

Figure 3 shows the basic structure of trade block. This block describes the relationship among domestic output, import, export and domestic consumption and characterizes export behavior of firms and import behavior of consumer-side. We use Constant Elasticity of Transformation (CET) function to simulate the domestic enterprises' behavior: to export or to supply for domestic consumption (domestic output for domestic consumption, DO for DC). Like other literature, we adopt Armington assumption to describe the behavior of consumption-side (Hansen, Schultz-Nielsen, and Tranæs 2017; Li, Liu, and

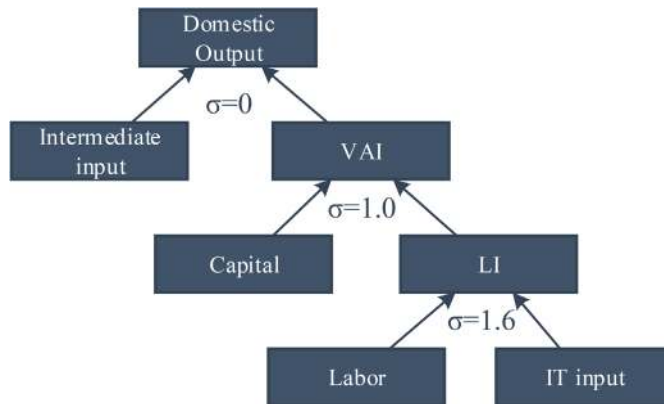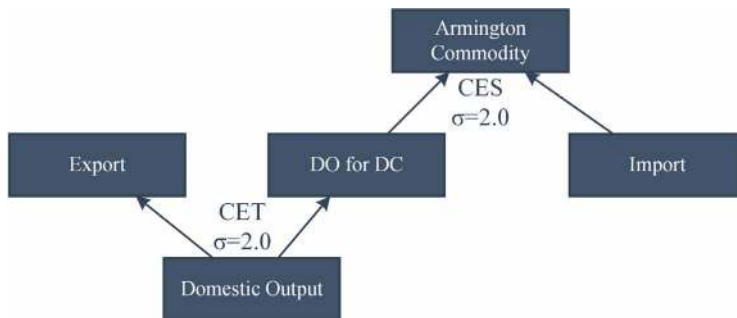**Figure 2. A framework of production block**

Figure 3. The framework of trade block

Song 2019). A CES function bundle has been used to composite DO for DC and import to domestic consumption. Elasticity in CES and CET function is set according to (Hosoe 2004).

3.1.3. Income-Expenditure Block

This block is used to describe the cash flow of different activities (government, enterprises, household and the rest of the world), shown in Figure 4. Household gets income from enterprises to pay direct tax and consumption (both domestic and international commodities), and the remaining income is turned into savings. Government's revenue is from direct tax, indirect tax and tariff and all of them are used for consumption, transfer payment and savings. The income of enterprises comes from export and domestic consumption and all the income will be used for remuneration of households, indirect tax and savings. Rest of the world get income from consumption, buy goods from domestic enterprises and pay for tariff, and unbalanced cash flow creates a trade surplus.

3.1.4. Macroscopic-Closure and Market-Clearing Block

To make CGE model get a unique optimal solution, this paper follows principles of macroscopic closure and market clearing. For macroscopic closure, we assume that savings are equal to total investment. In addition, this paper represents 2 market clearing conditions: one is the market clearing of the Armington composite commodity, the other is the clearing of the factor market. The former describes that all Armington commodities are used for consumption, investment and intermediate

Figure 4. The structure of income-expenditure block
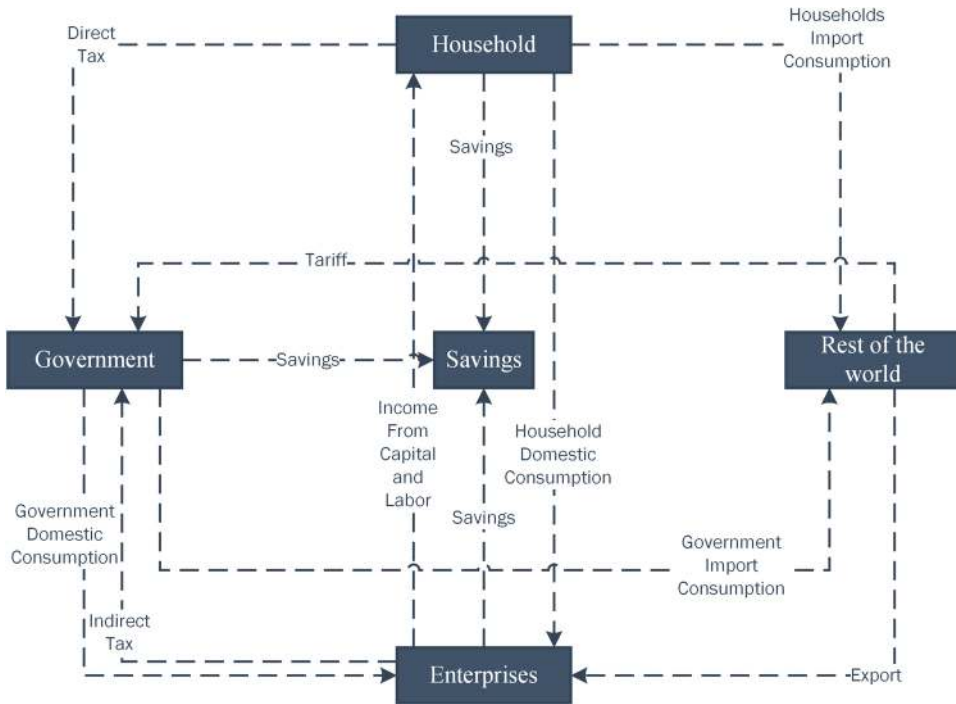
input. The latter assumes that the sum of capital and labor input in various industries is equal to the endowment of capital and labor.

3.1.5. Dynamic

As CGE is a static model, this paper uses the recursive method the dynamic model. This paper considers three parameters to dynamic: labor, capital and total factor productivity. All of them are exogenous parameters in the model. Labor endowments are set according to the National Population Development Plan (2016-2030) (The Central People's Government of the People's Republic of China 2017). The calculation of total capital per year is based on the perpetual inventory method:

$$K_{i,t} = K_{i,t-1} \times \left(1 - depre\_rate_i\right) + INV_{i,t-1}$$

where $K_{i,t}$ is the capital input (capital depreciation) in sector i at period t. $K_{i,t-1}$ is the capital input (capital depreciation) in sector i at period $t-1$. $depre\_rate_i$ represents capital depreciation rate in sector i. $INV_{i,t-1}$ denotes investment in sector i.

Total Factor Productivity (TFP) is also considered in this paper. The dynamic method of TFP is set according to Lou (2015), as shown in Table 1.

3.2. Data Source and Sectorial Classification

China Input-Output Table (CIOT) is used to construct Social Accounting Matrix (SAM), which is a basic data of CGE model (China Input-Output Association 2015). We reclassify the 42 sectors in the

Table 1. The growth rate of TFP in all sectors

Sectors	Growth Rate of TFP
AGR	5.0%
MIN	3.6%
MFT	4.0%
ELC	4.7%
CST	1.2%
TRA	6.6%
INT	10.0%
FNC	12.0%
EDU	2.1%
PSS	1.2%
OSE	5.3%

CIOT into 11 sectors by keeping the major downstream of the information industry and the industry with a relatively large input in information technology, as shown in Table 2.

We have also carried on some simple basic analysis to exhibit which industries mainly affects information industry, and which industries are mainly affected by the information industry, as depicted in Figure 5 and Figure 6. Figure 5 shows the primary source of income in information industry. We can find that the income of information industries is main from itself, finance, construction, manufacturing, households and public service, accounting for 80% of total revenue. What readers need to know is why the biggest source of income is itself: information industry includes kinds of firms and many transactions generated by enterprises all belonging to the information industry, so that part of transactions are counted in the intermediate input (INT-INT) items in the input-output table. For example, transactions between telecommunications companies and data processing companies.

Table 2. Abbreviations and descriptions of sectorial classification

Abbr.	Industries
AGR	Agriculture, forestry, animal husbandry and fishery
MIN	Mining industry
MFT	Manufacturing
ELC	Electricity and heat production and supply
CST	Construction
TRA	Transportation
INT	Information transfer, information software and information technology services
FNC	Finance
EDU	Education
PSS	Public administration, Social security and Social organization
OSE	Other services
HOH	Household

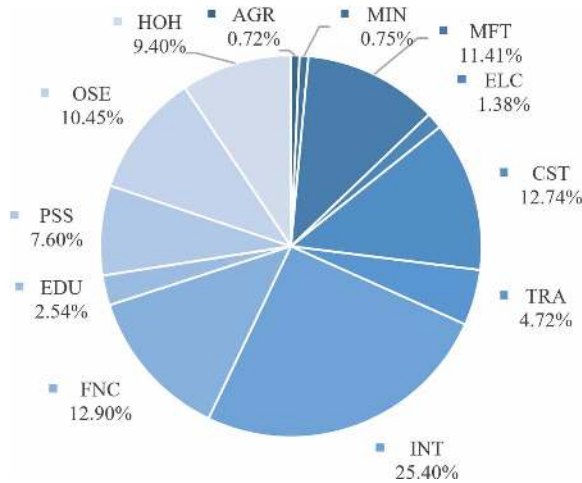**Figure 5. The primary source of income in information industry**

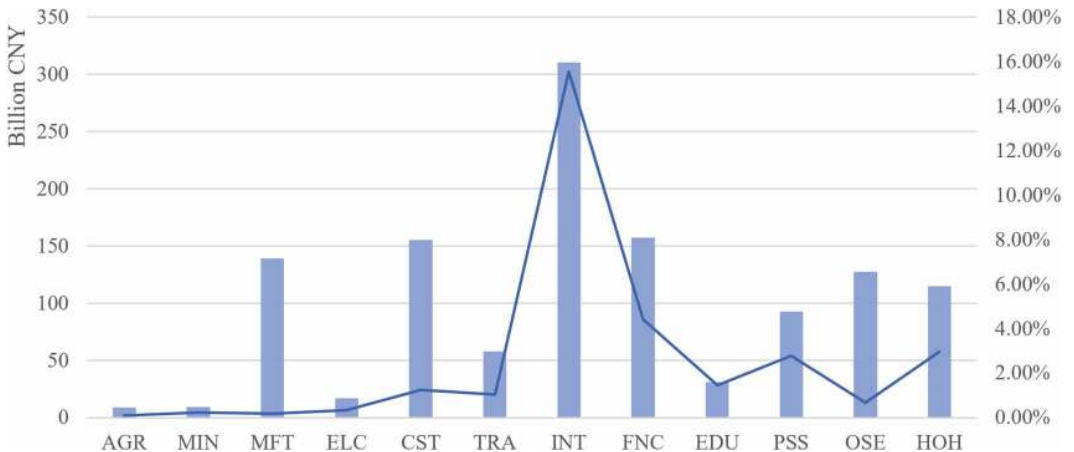**Figure 6. IT input and its rate to total input in all sectors**

Figure 6 illustrates IT input in all sectors and the rate to total input, which may show us what sectors will be affected by information-industries more than other sectors. We can find that information industry, finance, household, public service, education and construction may be easily affected by information industry, the rates of IT input to total input in these sectors are 15.56%, 4.41%, 2.97%, 2.79%, 1.44% and 1.24%, respectively. There are some differences compared with Figure 5: although IT input in the manufacturing sector is large relative to other industries, however, the proportion of it is small in manufacturing sector.

4. SCENARIO DESIGN

The core of this paper is to simulate the development of the information industry and explore what will happen to society. Thus we create 3 scenarios to simulate the development by changing total factor productivity in the information industry. First, we create a Bussiness as Usual (BaU) scenario, the exogenous variables are set according to Section 3. Next, we assume that the growth rate of TFP

Table 3. Different TFP in the design of the scenarios

Scenario	The Growth Rate of Total Factor Productivity
BaU	10%
S+	20%
S++	40%

will double in S+ scenario and quadruple in S++ scenario. The main reason for the radical design of growth rate in S++ scenario is that the information industry is an emerging industry in China, so the growth rate of total factor productivity is likely to be high like this.

5. RESULTS AND DISCUSSION

5.1. GDP

Figure 7 shows GDP in all scenarios from 2017 to 2030. We can find that GDP will be 175.43 trillion CNY in 2030 BaU scenario, the annual growth rate is 6.57%. The growth rate is highest in 2017, by 7.15% and lowest in 2030, by 6.27%. In 2030 S+ and S++, GDP will be 178.33 trillion CNY and 180.15 trillion CNY, respectively. Compared with BaU scenario, GDP will increase by 2.89 and 4.72 trillion CNY in scenarios of S+ and S++ scenarios, or 1.62% and 2.62%, respectively. We found that the development of information industry will rapidly promote economic development. But why is this happening? This paper will explain the reason in the perspective of sectors, households and government.

Figure 8 shows the changes of contribution value of different industries to GDP in different scenarios. We use expenditure method to calculate GDP of various industries in Figure 8 and the GDP in Figure7. We found that the development of information industry will directly increase the contribution of the industry to GDP. At the same time, it promotes the contribution of construction, transportation and other services. It is obvious that the development is conducive to economic transformation. The contribution of agriculture, mining and manufacturing industries will fall to some extent and the contribution of others will increase. However, the contribution isn't equal to economic output, as the contribution is calculated by final consumption, investment, and net export. Thus, we will discuss the impact of sectorial output in section 5.3.

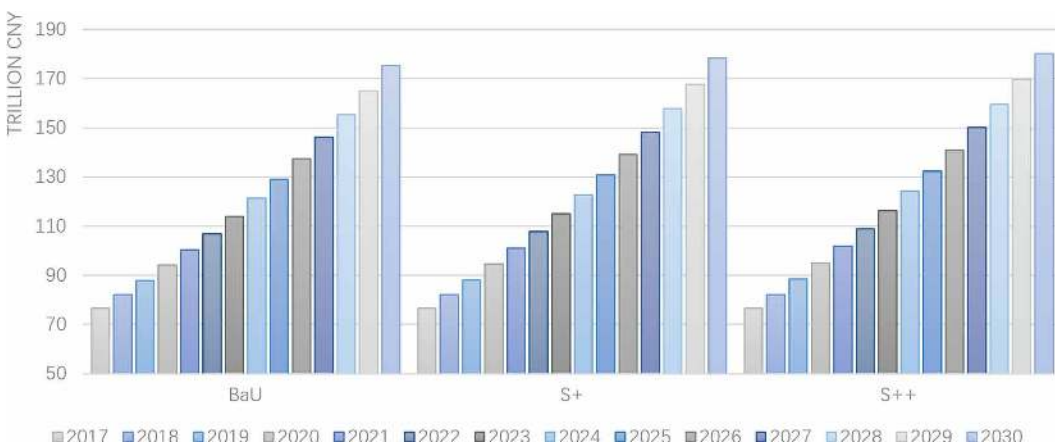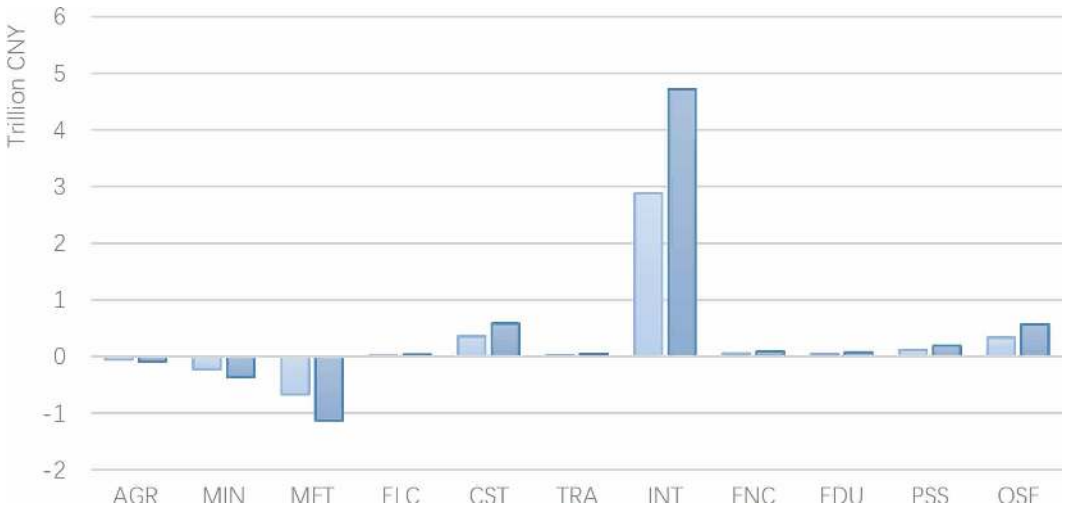Figure 7. GDP in all scenarios from 2017 to 2030

Figure 8. The changes of contribution to GDP of various industries inm 2030


5.2. Commodity Price

The variation of commodity price compared with BaU scenario in 2030 is illustrated in Figure 9. As the development of information industry, the price of the goods will decrease sharply, by 15.79% and 22.96% reduction in S+ and S++ scenario, respectively. Other industries will reduce their price too as the cost of information technology, by 0.34%-1.58%. We found that the development of information industry will directly impact on the product price in information industry. The main reason is that with the increase of productivity, marginal cost will decrease and the output will increase gradually, leading to supply-demand relationship changes, and finally resulting in the decline of product prices.

Moreoever, we found that the product price of agricuture will be less affected by the development of information industry, by 0.34%-0.58% reduction. The price of mining, electricity, construction, finance and public service will be affected more than other indutries, by 1.55%-1.59%, indicating that marginal revenue of IT input in these industries will higher than others. The research and development of information technology can serve more for these industries, which may be more conducive to the

Figure 9. The variation of commodity price compared with BaU scenario in 2030
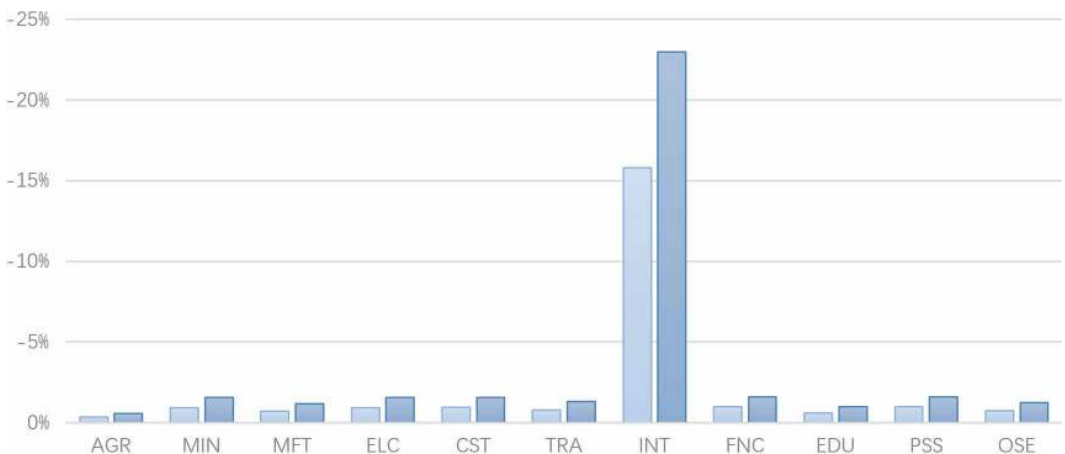
sound development of the information industry. In traditional energy and resource industries (such as mining and electricity industries), the degree of informatization is very low so that even a small amount of digital services can bring greater benefits to the industry. Relatively speaking, construction, finance and public services are inherently more dependent on information services, so the development of the information industry is also beneficial to their cost reduction.

5.3. Sectorial Output

The variation of sectorial output in S+ and S++ scenarios relative to BaU scenario in 2030 is depicted in Figure 10. The bar and the left ordinate represent the increase of output in different industries. The polyline and the ordinate on the right represent the growth rates of different industries. Information industry will increase its output by 4.43-7.30 trillion CNY. And manufacturing will increase the output by 3.42-5.58 trillion CNY, because the Chinese manufacturing industry is enormous although the growth rate is only 1.19%-1.94%. Finance, public service, electricity production and other services will increase their output more than other industries, by 2.18-3.58%, 1.59-2.56%, 1.56-2.57% and 1.69-2.79%, respectively. In general, the development of information industry mainly stimulates the development of the tertiary industry, followed by the secondary industry. Moreover, combined with the previous analysis, we found finance, public service, electricity production are sensitive to the development of information industry.

According to this section's result, we find that the strategy of developing information industry should focus on the support technology for manufacturing, finance, public service and electricity industries. For manufacturing, automation technology is the key to improve production efficiency. For finance, analysis based on big data and machine learning is a potential point of economic growth and a potential direction of enterprise expansion. For electricity, optimization power flow analysis, construction of smart grid, and construction of energy Internet need the support of information industry. All of these technologies above may be opportunities for expansion of the digital industry.

5.4. Households Consumption

The changes of household consumption are illustrated in Figure 11 and the spillover effect of the development of the information industry on household consumption is shown in Figure 12. The increased consumption are concentrated on information products, which is 685.19-1089.14 billion CNY, the next are manufacturing products and other services, by 171.50-297.85 billion CNY and 163.51-282.50 billion CNY, respectively. Household will increase the consumption in all goods

Figure 10. The variation of sectorial output compared with BaU scenario in 2030
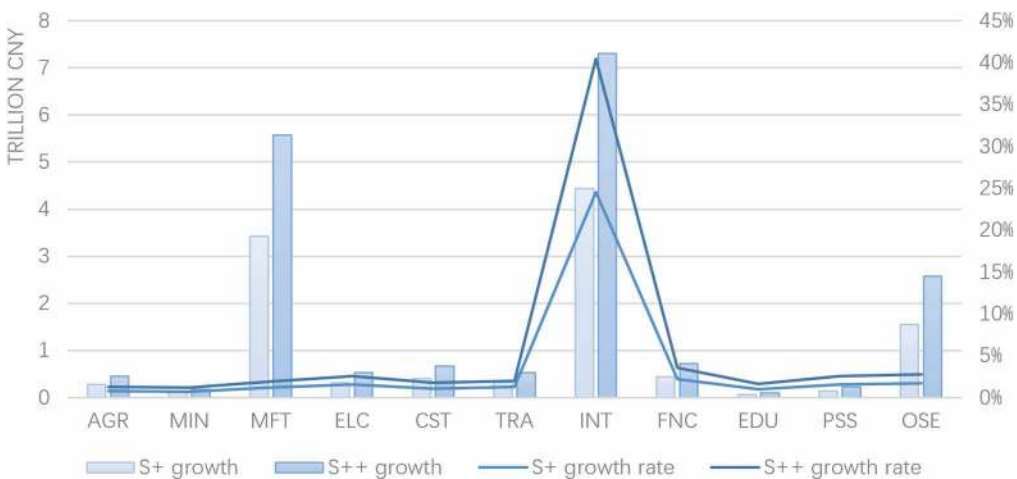
Figure 11. The variartion of household consumption relative to BaU scneario in 2030
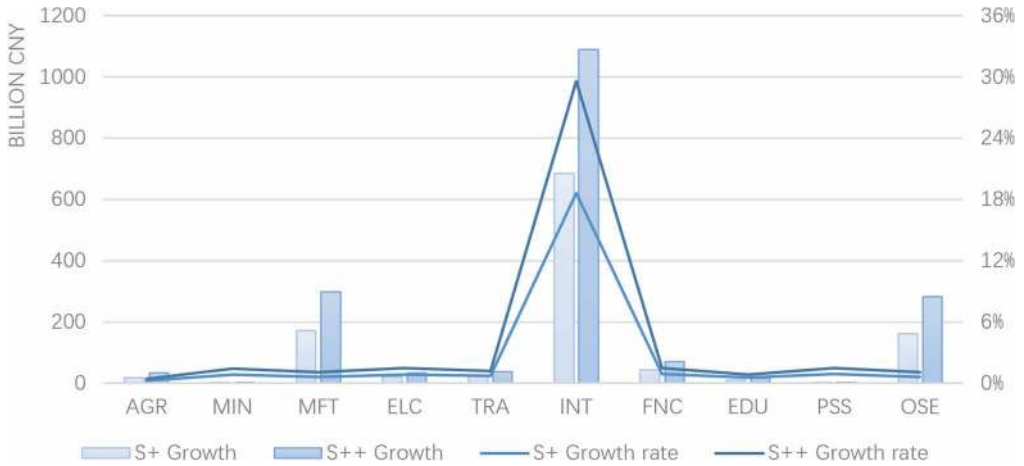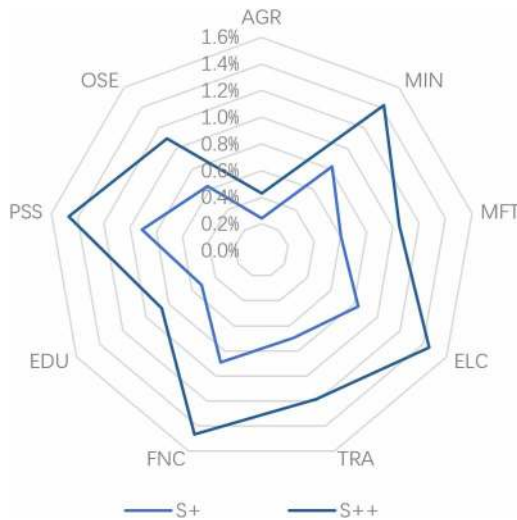

Figure 12. The spillover effect of the development of the information industry on household consumption

caused by lower prices of the commodities, especially in information products, equipment, and other services. To research the spillover effect of the development of information industry on residents' consumption, this paper draw a figure to present change rate of household consumption after removing information products, see Figure 12. Aside from mining products that have little consumption of households, electricity, finance and public services are subject to spillover effects more significantly, indicating that people are more willing to buy electricity and financial products under the development of information industry.

5.5. Government Revenue

Figure 13 illustrates the changes of government revenue in 2030. The results show that government will increase the revenue by 65.08 trillion CNY and 103.60 trillion CNY in S+ and S++ scenarios. The government's increased income is mainly derived from indirect taxes: indirect tax will increase

Figure 13. The variation of government revenue in S+ and S++ scenarios in 2030
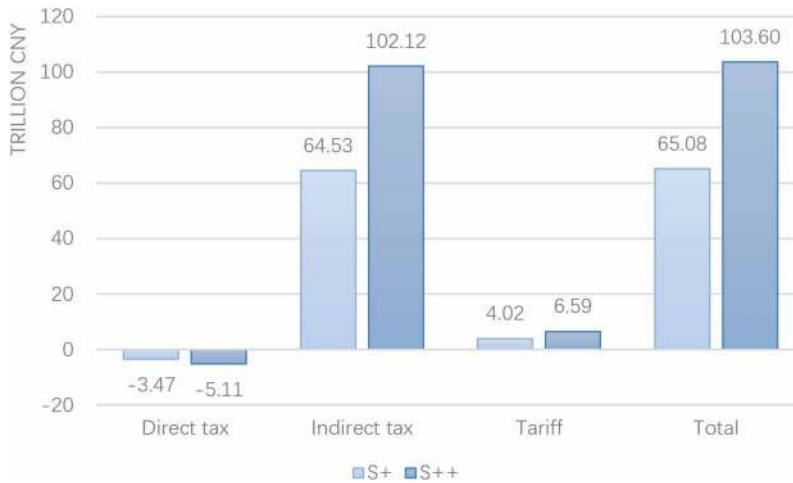
by 64.53-102.12 billion CNY, while tariff will increase by 4.02-6.59 billion CNY and direct tax will reduce by 3.47-5.11 billion CNY. It is clear that the development of information industry will be helpful for enterprises to improve output and also be helpful for government to raise tax revenue.

Why will the direct tax decrease while others increase? We found that the development of information industry will reduce capital price by 1.33%-2.66% compared with the price in BaU scenario, indicating that income of household will reduce, so that direct tax will be reduced a little. Then the question is, why will capital price reduce? The development of the information industry has led to a certain substitution of capital demand in various industries (such as the transfer of documents is from mailing paper documents to transmitting electronic files, resulting lower the overall cost, although the degree of substitution is not very large). Why is the tariff rising a little? Mainly because of the decline in enterprises costs, resulting in increased exports, so that residents and firms have more money to buy foreign products.

Moreover, we explored the composition of the increased direct tax. Figure 14 illustrates the structure of increased direct tax. Tax from services accounts for more than half, among them, information industry accounted for 10.2%, financial industry accounted for 7.3% and other services accounted for 46.2%. Manufacturing also contributes 28.9% of total increased indirect tax. From the structure we can also find some evidence that information industry could help for economic transformation.

5.6. Social Welfare

Figure 15 illustrates social welfare in S+ and S++ scenario in 2030. With the help of social welfare indicators of Hicksian equivalent variation (Weber 2010), we can convert the utility into the utility level measured by currency, thus we can quantitatively evaluate welfare improvement, and can measure the overall welfare of the economy. The result shows that social welfare will increase by 1.49% and 2.43% in S+ and S++ scenarios, respectively. We found that the development of information industry is good for social welfare but marginal rate of return is decreasing as the level of development rises. Readers may ask why residents' incomes will fall, but social welfare will rise? We explored the rate of decline in households' income, which is 0.1% in S+ and S++ scenarios, however, the price of goods (Figure 9) will reduce from 0.34%-22.96% in the two scenarios.

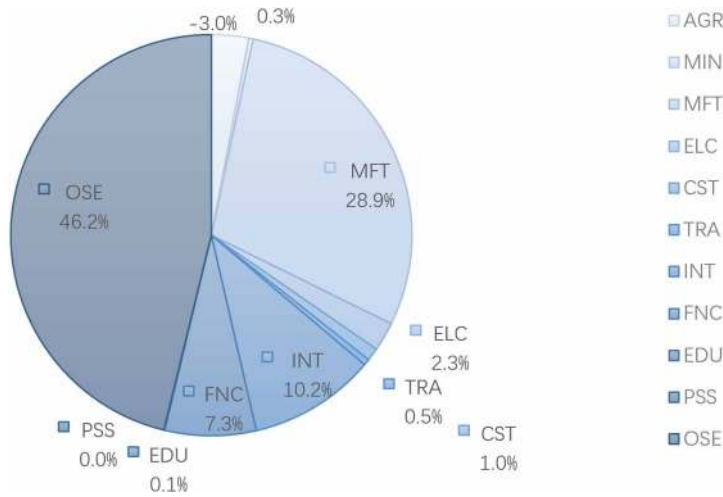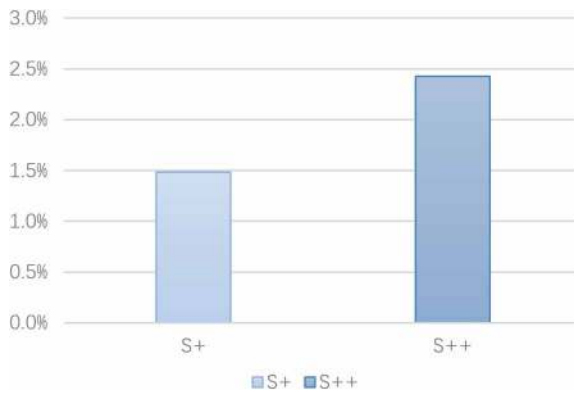**Figure 14. The structure of increased direct tax**

Figure 15. Social welfare in 2030

6. CONCLUSION AND IMPLICATION

6.1. Conclusion

The information industry is the benchmarking industry for social digitalization. This paper aims to assess the economic impact of information industry development by applying a dynamic recursive computable general equilibrium model, and draws several conclusions.

GDP will increase by 1.62-2.62% and social welfare will increase by 1.49-2.43% in S+ and S++ scenarios, respectively, indicating that the development of information industry will rapidly promote economic development. The development of the information industry can promote the decline of commodity prices and the rise of output by providing higher social productivity. The development of information industry mainly stimulates the development of the tertiary industry, followed by the secondary industry. Moreover, finance, public service, electricity production are sensitive to the development of information industry, which means these industries will benefit the most when the information industry develops rapidly. Similarly, people are more willing to buy electricity and financial products under the development of information industry, not to mention information

products. Government will increase the revenue by 65.08 trillion CNY and 103.60 trillion CNY and enterprises are the main contributors. Tax from services accounts for more than half, meaning that development of information industry could help for economic transformation.

6.2. Implication

The information industry is a basic industry of the national economy. The development of digital industry is innovative and powerful, and plays an important role in transforming the development mode and stimulating economic growth. We confirm that the development of information industry is good for the economy. Developing the information industry is necessary to an emerging country.

The conclusion shows that the development of IT will reduce the labor price, which means there is a relative strong substitution relationship between labor input and IT intput. From the government's point of view, the reduced demand of labor force would cause higher unemployment. Improving the time and quality of education may be the solution. From the enteprises' point of view, before the arrival of comprehensive information war between industries, it is very necessary to seize high-quality employees.

According to the results in section 5.3, in the direction of the investment to the information industry, we found that some traditional energy industry (such as electricity) and finance industry is sensitive to the development. The benefits of the financial industry are self-evident. The benefits of the electricity industry are mainly in the construction of power generation automation and smart grid. Therefore, the information industry can strengthen R&D input in industrial control embedded software products, cloud computing technology and emergency communication for these traditional industries, which could increase industry income easily, improve social production efficiency, and liberate part of the labor force. Another, we found that the development of IT will reduce the capital price. There seems to be a substitution between IT input and capital input. This is also a reflection of the more efficient capital after informatization.

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APPENDIX A: DESCRIPTIVE CHART

Figure 16. Number of Internet users and turnover of online shopping in China
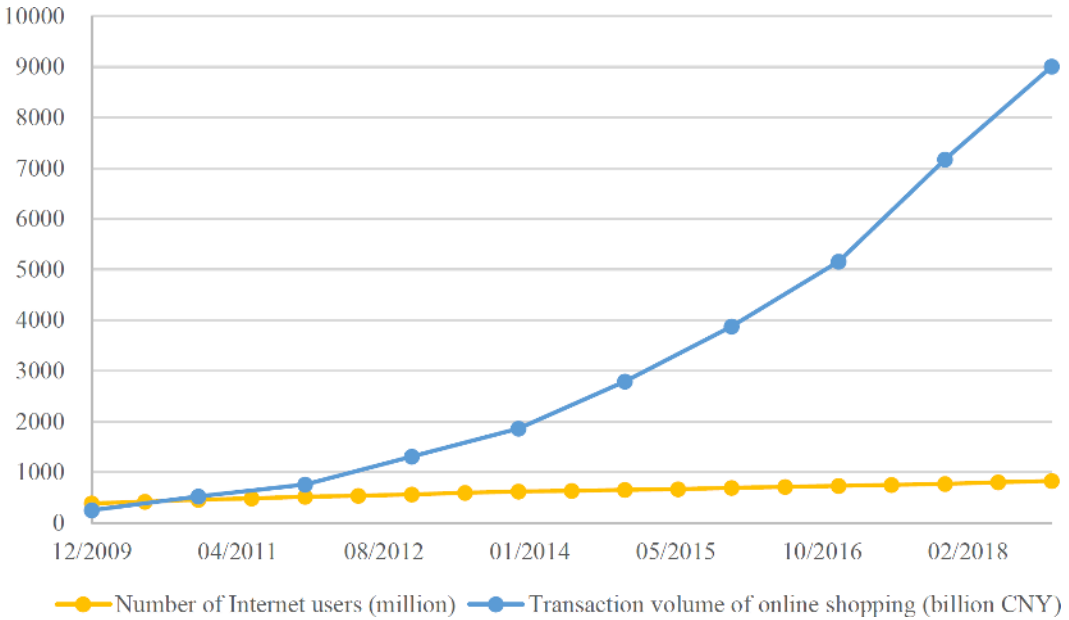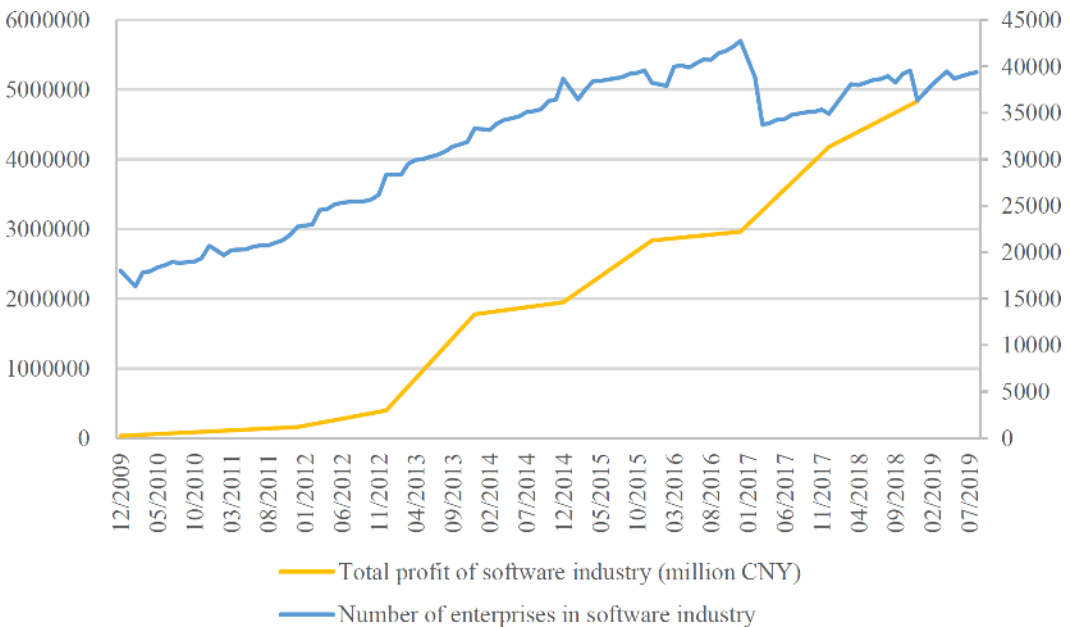

Figure 17. Number of enterprises in software industry and total profit of software industry

APPENDIX B: FRAMEWORK OF CGE MODEL IN THIS PAPER

B.1 Production Block

$$LI_i = \alpha_i^{li}[\delta_i^{li} Labor_i^{\rho_i^{li}} + (1-\delta_i^{li})ITinput_i^{\rho_i^{li}}]^{1/\rho_i^{li}} \quad \text{(B.1)}$$

$$\frac{PLabor_i}{PITinput_i} = \frac{\delta_i^{li}}{1-\delta_i^{li}}\left(\frac{ITinput_i}{Labor_i}\right)^{(1-\rho_i^{li})} \quad \text{(B.2)}$$

$$LI_i PLI_i = Labor_i PLabor_i + ITinput_i PITinput_i \quad \text{(B.3)}$$

$$VAI_i = \alpha_i^{vai}[\delta_i^{vai} Capital_i^{\rho_i^{vai}} + (1-\delta_i^{vai})LI_i^{\rho_i^{vai}}]^{1/\rho_i^{vai}} \quad \text{(B.4)}$$

$$\frac{PCapital_i}{PLI_i} = \frac{\delta_i^{vai}}{1-\delta_i^{vai}}\left(\frac{LI_i}{Capital_i}\right)^{(1-\rho_i^{vai})} \quad \text{(B.5)}$$

$$VAI_i PVAI_i = Capital_i PCapital_i + LI_i PLI_i \quad \text{(B.6)}$$

$$INT_{i,j} = a_{i,j}^{INT} Z_j \quad \text{(B.7)}$$

$$VAI_j = a_j^{VAE} Z_j \quad \text{(B.8)}$$

$$PZ_j = a_j^{vae} PVAI + \sum_i a_{i,j}^{INT} PQ_i \quad \text{(B.9)}$$

B.2 Income-Expenditure Block

$$SP_l = ss_l^p \sum_i \left(\gamma_l^{lab} LAB_i \cdot PLAB_i + \gamma_l^{cap} CAP_i \cdot PCAP_i\right) \quad \text{(B.10)}$$

$$SG = ss^g \left(\sum_l TD_l + \sum_i TZ_i + \sum_i TM_i\right) \quad \text{(B.11)}$$

$$XP_{i,l} = \frac{\beta_{i,l}^{xp}}{PQ_i}\left[\sum_i \left(\gamma_l^{lab} LAB_i \cdot PLAB_i + \gamma_l^{cap} CAP_i \cdot PCAP_i\right) - SP_l - TD_l\right] \quad \text{(B.12)}$$

$$XG_i = \frac{\mu_i}{PQ_i}\left[\sum_l TD_l + \sum_i TZ_i + \sum_i TM_i - SG\right] \quad \text{(B.13)}$$

$$TD_l = \tau_l^d \sum_i \left(\gamma_l^{lab} LAB_i \cdot PLAB_i + \gamma_l^{cap} CAP_i \cdot PCAP_i\right) \quad \text{(B.14)}$$

$$TZ_i = \tau^z PZ_i Z_i \quad \text{(B.15)}$$

$$TM_i = \tau^m PM_i M_i \quad \text{(B.16)}$$

B.3 Trade Block

$$PE_i = \varepsilon PWE_i \quad \text{(B.17)}$$

$$PM_i = \varepsilon PWM_i \quad \text{(B.18)}$$

$$\sum_i PWE_i E_i + SF = \sum_i PWM_i M_i \quad \text{(B.19)}$$

$$Q_i = \gamma_i \left(\delta m_i M_i^{\eta_i} + \delta d_i D_i^{\eta_i}\right)^{1/\eta_i} \quad \text{(B.20)}$$

$$M_i = \left[\frac{\gamma_i^{\eta_i} \delta m_i PQ_i}{(1+\tau_i^m)PM_i}\right]^{\frac{1}{1-\eta_i}} Q_i \quad \text{(B.21)}$$

$$D_i = \left[\frac{\gamma_i^{\eta_i} \delta d_i P Q_i}{P D_i} \right]^{\frac{1}{1-\eta_i}} Q_i \ \text{(B.22)}$$

$$Z_i = \theta_i \left(\xi e_i E_i^{\phi_i} + \xi d_i D_i^{\phi_i} \right)^{\frac{1}{\phi_i}} \ \text{(B.23)}$$

$$E_i = \left[\frac{\theta_i^{\phi_i} \xi e_i (1 + TZ_i / Z_i / PZ_i) PZ_i}{PE_i} \right]^{\frac{1}{1-\phi_i}} Z_i \ \text{(B.24)}$$

$$D_i = \left[\frac{\theta_i^{\phi_i} \xi d_i (1 + TZ_i / Z_i / PZ_i) PZ_{ii}}{P D_i} \right]^{\frac{1}{1-\phi_i}} Z_i \ \text{(B.25)}$$

B.4 Macroscopic-Closure and Market-Clearing Block

$$XV_i = \frac{\lambda_i}{PQ_i} \left(\sum_l SP_l + SG + \varepsilon SF \right) \ \text{(B.26)}$$

$$Q_i = \sum_l XP_{i,l} + XG_i + XV_i + \sum_j X_{i,j} \ \text{(B.27)}$$

$$\sum_i LAB_i = \sum_l FF_l^{lab} \ \text{(B.28)}$$

$$\sum_i CAP_i = \sum_l FF_l^{cap} \ \text{(B.29)}$$

B.5 Objective Function

$$TOTUU = \sum_l \left(\prod_i XP_{i,l}^{\alpha_{i,l}} \right) \ \text{(B.30)}$$

APPENDIX C: DATA DESCRIPTION IN SAM

The accounts in Table 4 are the sub account in Activity account in Table 5. Table 4 reflects relationship between different sectors, and Table 5 expresses the relationship between different social subjects (rural residents, urban residents, government and rest of the world).

Table 4. Intermediate input of all the industries in this paper

	AGR	MIN	MFT	ELC	CST	TRA	INT	FNC	EDU	PSS	OSE
AGR	1534	3	6103	1	136	100	6	0	15	0	458
MIN	1	892	6543	1411	101	7	0	0	4	4	13
MFT	2371	1369	54308	818	6867	2363	747	407	243	546	6470
ELC	111	386	2356	2087	233	166	39	45	21	41	297
CST	1	16	138	26	465	61	14	64	14	53	231
TRA	134	161	2350	93	520	1096	39	157	71	237	845
INT	11	11	167	21	185	71	386	195	38	113	154
FNC	134	220	1241	308	431	584	125	454	97	114	1114
EDU	1	3	20	1	8	5	2	37	37	33	26
PSS	4	3	45	1	6	4	6	7	4	23	52
OSE	268	352	5526	203	1196	572	408	2086	183	507	4414

Table 5. Simplified SAM in this paper

	Activity	**CAP**	**LAB**	**IDT**	**TRF**	**HOH**	**GOV**	**INV**	**ROW**
Activity	128623					21381	8881	22092	16985
CAP	9259								
LAB	35076								
IDT	9429								
TRF	273								
HOH		9259	35076						
GOV				9429	273	3117			
INV						19837	3938		-1683
ROW	15302								

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