Industrial structure and productivities in a two-sector growth model

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Abstract:

We set up a model of heterogeneous-producers based on the semi-rival technology to study how industrial structure transforms and different sectional productivities. In a fully market-oriented economy, the industrial structure is endogenous and sectional productivities are the same. Employing fiscal subsidies to different industries lead to changes in both industrial structure and productivities, while the growth rate and interest rate keep fixed. For plausible values of parameters, the benchmark model generates results consistent with the United States' data, and the extension model partly explains China's industrial transformation and changes of industrial productivities.

I. Introduction

According to classic "Kaldor Facts" (Kaldor, 1961), labor-output ratio, which is defined as the labor's productivity in many literatures, is a constant. In the neoclassical growth theory stemming from Lucas (1988) and Romer (1986, 1990), growth rate of labor-augment technologies which is not zero, equals to growth rate of labor productivity. These results lead to the productivity not be constant any more. "New Kaldor Facts" recently proposed by Jones and Romer (2010) with human capital growing, wage to human capital is relatively stable. If we regard human capital or technology-augment labor as one kind of advanced labor and human capital's wage equals to its marginal output, the productivity of advanced labor in neo-growth theory will be constant.

On the other side, because productivities in different industrial sections vary in real economy, using the one section growth model is not suitable for explaining these structural changes. To implicate the structure transformation, some literatures based on the non-balance analysis, and presumed that sections have different growth rates, such as Kongsamut, Rebelo and Xie (2001), Acemoglu and Guerrieri (2008). Other literatures based on steady state equilibrium, same growth rates of sections should be presumed. As in Uzawa's (1964) first structural analysis, section growth rate are generally assumed exogenously the same, Herrendorf, Rogerson and Valentinyi (2013) assumed that sections have same growth rate.

To analyze the economic structure transformation is a very striking research field in growth theory recently, which explains how production factors, such as labor, capital outflow from agriculture into industry and service. These literatures starting to analyze economic structure transformation can be divided into two directions. One direction is that they based on the demand side to explain the structural transformation by agent's preferences and economic growth was not on the balance path. These literatures generally derived different section constant economic growth rates by agent having non homothetic preferences. Seminal structural analysis by Kongsamut, Rebelo and Xie (2001) showed an implication that different sections' growth paths depending on the agent have Stone-Geary preferences over agricultural, industrial and service goods[1]. Foellmi and Zweimuller (2008) used the hierarchic preference and sectional difference in income elasticities of demand across sections to explain the structural transformation. The other direction is that some sound studies explain structural transformation from production side, such as technology. Ngai and Pissarides(2007, 2008) show, in a dynamic framework, that labors outflow from agricultural section to industrial and service section because the latter sections have higher TFP than that of the former. Though Ngai and Pissarides' work is seminal and reasonable, the insight implication on multi-section growth purposed by Ngai and Pissarides does not explain why sections use different levels of technology. If there is no implediment in factor mobility, multi-sections will converge to one section in the framework of different growth rates of sections. Buera and Kaboski (2008b) recognized that scale technologies lead to industrial section expansion and service section shrinkage.

The different expansion of sections can be explained by many reasons, such as difference of technology in sections (Ngai and Pissarides(2007, 2008)), impediment of labor mobility in sections (Lee and Wolpin, 2006) or spatial difference (Krugman, 1991, Lucas, 2009), changes of relative prices and income effect (Herrendorf, Rogerson and Valentinyi, 2013). A worth-noting cause is that government industrial

[1] Similar papers are Laitner (2000), Echevarria (1997).

policies have great influence on economic structure transformation, especially in countries of the government-leading type, such as China. In China, central and local governments can use variant taxation policies to incentivize one section to expand or cut down other sections' output proportion in the whole economy in the process of development.

Our paper also bases on the production side and different from nonbalance analyses of Ngai and Pissarides (2007, 2008), Acemoglu and Guerrieri (2008) instead of steady states analysis. Our paper makes sectional technologies endogenous by introducing exchange of technology between manufacturing section and service section. We find that growth rates of both sections are the same, which means output proportion of sections is stable to keep economic structure stable. One important assumption in our paper is that technology is semi-rival, technology is rival for the manufacturing section and non-rival for the service section. We find that the economic structure, such as ratios of capitals, labors and outputs between two sections, is dependent on the coefficients of production and consumption; The economic structure will change along with unchangeableness of economic growth and interest rate corresponding to disparate taxation and subsidies policy by fiscal authority.

In this paper, we present a two-section model, and both sections have the same growth rate with different allocation of capital stock, labor and output. We assume that capital only comes from manufacturing section as Kongsamut, Rebelo and Xie (2001), and that nonrivalrous technology comes from service section. Both manufacturing and service sections use technology, capital and labor to produce. The product of manufacturing section can be reserved for future production and product of service section is only used for current consumption. Technology production uses human capital and technology itself as Grossman and Helpman (1991), Aghion and Howitt (1992), Jones（(2002), Fernald and Jones（2014）. Manufacturing section uses capital to trade for service section's technology. We show that both sections have the same growth rate and productivities, while sectional ratios of capital, labor and output are different in the benchmark model, and in extension analysis, sectional productivities change led by fiscal authority's disparate policy.

The rest of this paper is organized as follows, section II presents a two-section growth model and all steady equilibrium solutions to implicate the economic structural issue. Section III is an extension which shows exogenous variables, diversity of fiscal policy in both sections, how to affect the economic structure. Section IV undertakes a simple calibration under the benchmark model and the extension to compare how fiscal policy makes economy transform structurally. Section V is the conclusion.

II. The benchmark model: An economy with two sections

In this section, we present an endogenous technological production two-section model based on the steady states which is different from the previous researches as Kongsamut, Rebelo and Xie (2001), Acemoglu and Guerrieri (2008) built on the nonbalanced growth path.

As Kongsamut, Rebelo and Xie (2001), manufacturing goods are durable and service goods are perishable, consequently, capital accumulation only comes from the manufacturing section. The service section has two functions: one is to produce the service goods, the other function is to produce the technology[2]. Because both sections' goods productions need to use capital and technology as production factors, they will purchase capitals in competitive capital market. For manufacturing section, it buys the technology directly from the service section. In parallel, the service section can acquire directly the technology in its own section without payment. We call this kind of feature of technology semi-rival, rival for the manufacturing section and non-rival for the service section. The household owns all capitals, final goods and human capital invested into the technology production, in order to reach its long term optimal, the household makes plan on the allocation of its consumption, capital investment and human capital investment.

We give a detailed logic relationship of the benchmark model in fig 1.

[2] In national income statistic, the service products include the service final goods and semi-rival technology product. The semi-rival technology in the service sector also has the price which can be given statistically.

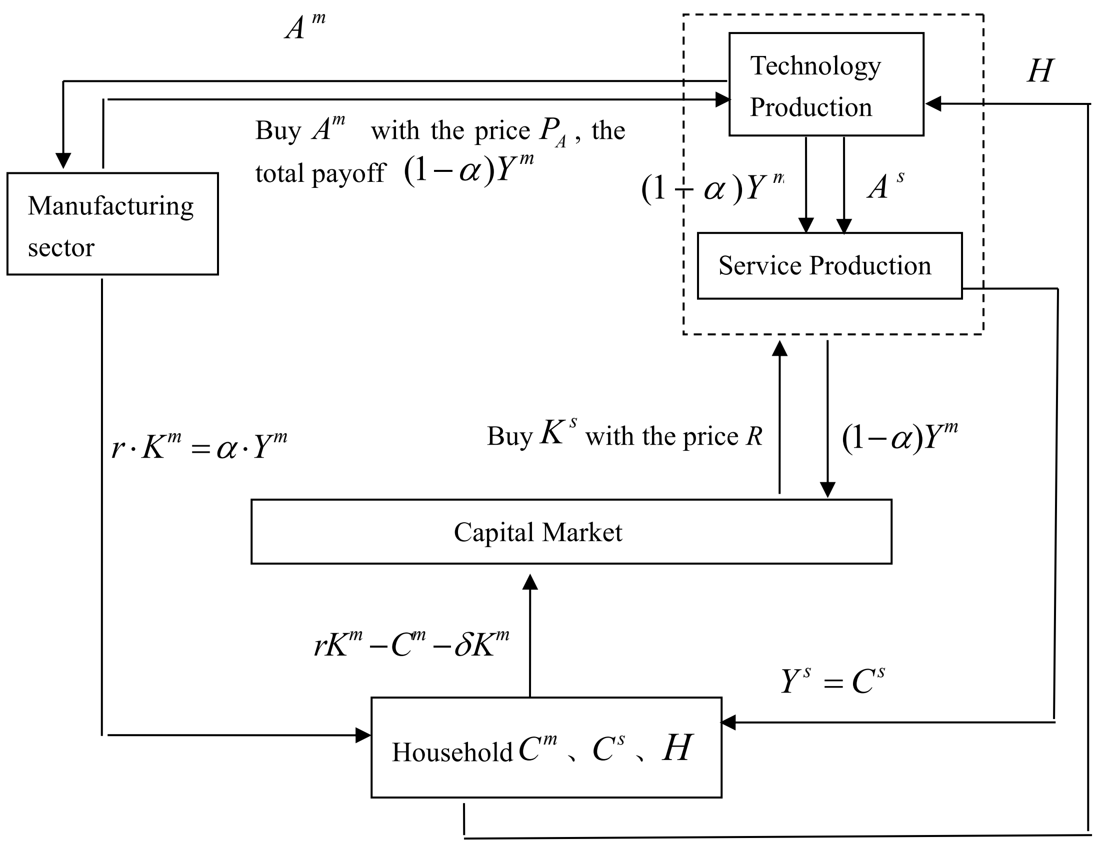

Fig 1 the logic of the benchmark model

A. Production

There are two sections to produce in the economy; respectively produces manufacture goods and service goods. The two section's production functions are constant return to scale as below

$$Y^m(t) = F(K^m(t), A^m(t), L^m) = [K^m(t)]^\alpha \cdot [A^m(t) \cdot L^m]^{1-\alpha} \quad (1)$$

$$Y^s(t) = F(K^s(t), A^s(t), L^s) = [K^s(t)]^\alpha \cdot [A^s(t) \cdot L^s]^{1-\alpha} \quad (2)$$

where $Y^s(t)$, $K^m(t)$, L^m, $A^m(t)$, $Y^s(t)$, $K^s(t)$, L^s and $A^s(t)$ are level of output, capital, labor and labor-augment technology used in two sections. The economy has a fixed labor level $\overline{L}$, so $\overline{L} = L^m + L^s$. Capitals in both sections are additive, satisfy $K^m(t) + K^s(t) = K(t)$. Labors and capitals are freely flow across sections through the competitive capital and labor market. And both sections face the same interest rate and wage.

We can obtain $Y^m(t)/Y^s(t) = L^m/(\overline{L} - L^m)$ by functions (1), (2), and the condition which both sections confront with the same interest rate in competitive capital market. $Y^m(t)/Y^s(t) = L^m/(\overline{L} - L^m)$ means that the proportion of manufacturing output and service output equals to the proportion of labors in manufacturing section and service section. And we define the proportion is n.

B. Technology

In this economy, labor-augment technologies in both manufacture and service productions come from the technology section which belongs to the service section, and the technology is something like know ledges and designs as non-rival intermediate input in service production as depicted by Romer(1990)[3]. In our paper, the technology is something as semi-rival goods. Technology in service section has two kinds of usage: service section can not only use technology as its own intermediate without paying but also sell the technology to the manufacturing section to exchange capitals which are used as the input in its own production, so the technology is non-rival for service section and rival for manufacturing section. Technological production takes form as Arrow (1962), Park (1998), Kosempel (2004).

$$\dot{A}(t) = A(t)^{\theta} H(t)^{1-\theta} \tag{3}$$

Generally speaking, there are two expressions to depict the engine of the long term growth. One is the non-rival technology such as Romer(1990), another expression is the human capital formation such as Lucas (1988). Both technology and human capital's motion equations are linear and the growth rates of technology and human capital are a constant. Jones（1995a, 1995b）gives one nonlinear function of the human capital motion equation expressed by stock of technology and human capital. It's easy to find out that when the elasticity of technology production function in Jones' literatures is zero, the equation of technology's motion is the same as these of Romer(1990), Grossman and Helpman(1991), Aghion and Howitt (1992). Another expression is using knowledge to substitute the human capitals in technology's motion function, such as Jones (2002), Fernald and Jones (2014).

According to Picard theorem, when the differential equation (3) satisfies the Lipschitz condition, the equation (3) will has a unique solution. Another explanation to the existence of a unique solution of (3) is that A and H is an increasing function and decreasing function respectively on $\dot{A}(t)/A(t)$; A and H is concave and convex respectively on $\dot{A}(t)/A(t)$. These conditions can guarantee g_A converging to a

[3] In China, technologies, depicted as Romer(1990), always origin specially from so called Shiye Danwei including all higher schools, Center government and State government's researching institutes. These institutes' operation expenses come from government's special appropriate funds, and most of these institutes sell their services to one or more special industries. In output statistic classification, these institutes classify the service sector.

constant when A and H increase to infinity.

C. Preference

The economy has a representative household with maximizing her long term utility function and there is no the population growth in household, the utility function as below

$$W = \int_0^\infty e^{-\rho t} \cdot U(C^m(t), C^s(t), H(t)) \cdot dt \tag{4}$$

where $U(C^m(t), C^s(t), H(t)) = \dfrac{[C^m(t)^\beta + C^s(t)^\beta)^{1/\beta} \cdot H(t)^{-1}]^{1-\sigma}}{1-\sigma}$

and $C^m(t)$, $C^s(t)$ are manufacturing and service consumption per capita at time t respectively, the $C^m(t)^\beta + C^s(t)^\beta)^{1/\beta}$ can be regarded as the composite of the consumption. ρ is the time preference and $1/\sigma$ is the elasticity of inter-temporal substitution, $1/(1-\beta)$ is the elasticity of substitution. As Turnovsky(2004), $H(t)$ is human capital invested in technological production by household. To acquire more human capital, the household has to spend more time on education and career training and decrease the leisure time. And without loss generality, we adopt the relationship of the composite of the consumption and the human capital to be a ratio in utility function.

D. competitive factor markets and exchange relationship for service section

We can image that the economy has two competitive factor markets: the capital market and the technology market. Because of characteristics of the rival technology for the manufacturing section, the manufacturing section purchases the technology in the technology market at the price P_A, and purchases capitals in the capital market at the price r. According to the Euler condition of production, we can obtain payoffs of the manufacturing section to two markets are respectively $(1-\alpha) \cdot Y^m(t)$ and $\alpha \cdot Y^m(t)$.

The service section, regarded as suppliers of technology, sells its technology at the price P_A in technology market, and purchases capitals at the price r in capital market. The relationship of exchange satisfies

$$P_A \cdot A^s(t) = r \cdot K^s(t) \tag{5}$$

Characteristics of semi-rival technology can not only keep the service section selling the technology to acquire capitals, but also make the service section use the technology as the factor input without paying.

The competitive technology market for the manufacturing section has an implicate effect that the payoff for the technology of the section equals to the share of the labor-augment technology manufacturing output and payoff for capitals in the capital market equals to the rest of manufacturing goods, or to say, the technology of the manufacturing section in one time spot can not be accumulated for the next time spot. Consequently, the manufacturing section has to purchase new technologies in the technology market continually.

E. Transition Equation of Capital

Products of service section are perishable goods (Non-durable Goods) which will be consumed all without reservation. And products of manufacturing section are durable goods. Hence the accumulation of capitals in the whole economy only comes from the manufacturing section. According to the Euler condition of manufacturing function, $Y^m(t) = F'_{K^m(t)} \cdot K^m(t) + F'_{A^m(t)} \cdot A^m(t)$, and characteristics of the competitive capital market, $F'_{K^m(t)} = r$, and the marginal output of labor-augment technology of manufacturing section equals to P_A, so the $F'_{A^m(t)} \cdot A_m$ is the manufacturing section's payoff to the technology market. The transition Equation of Capital is

$$\dot{K}^m(t) = r \cdot K^m(t) - C^m(t) - \delta K^m(t) \tag{6}$$

where δ is the discount rate of capital.

F. The Static Equilibrium

Both sections face the exogenous price *r* in the competitive capital market, and they simultaneously maximize their value of current profit function. By formulas (1), (2) and (5), we obtain

$$P_A = (1-\alpha) \cdot \frac{Y^m(t)}{A^m(t)} \tag{7}$$

$$r = \alpha \cdot \frac{Y^m(t)}{K^m(t)} = \alpha \cdot \frac{nY^m(t)}{K^s(t)} \tag{8}$$

combining formulas of (5), (6), (8), (9) and $Y^m(t)/Y^s(t) = L^m/(\bar{L} - L^m) = 1/n$, we obtain

$$n = \frac{1-\alpha}{\alpha} \tag{9}$$

The sizes of service and manufacturing productions are proportional in steady state, and we can also obtain the capital proportion of the service section and manufacture section is also $n = K^m(t)/K^s(t)$. n is a constant only expressed by α, which explicitly illustrates the household does not need to optimize *n* in the dynamic decisive process. In addition, equation (8) can be also shown as

$$\frac{Y^m(t)}{K^m(t)} = \frac{Y^s(t)}{K^s(t)} = \frac{r}{\alpha} \tag{10}$$

G. The household Planner's Problem

The household chooses the allocation of the composition of the consumption and stock of the capital, appropriates the human capital into the technology production. Household faces simultaneously the capital transition equation and technological transition equation and the constraint condition that the service consumption equals to service production as below

$$C^s(t) = F(K^s(t), A^s(t), \overline{L} - L^m - L^A) \tag{11}$$

The household makes (4) maximization as a social planner. The problem can be expressed as follows：

$$\underset{C_t^m, C_t^s, H_t, K^m(t), K^s(t), A(t)}{Max} \quad H^e = U(C^m(t), C^s(t), H(t)) + \lambda_m(t) \cdot [r \cdot K^m(t) - C^m(t) - \delta \cdot K^m(t)]$$

$$+\lambda_A(t) \cdot [A(t)^\theta \cdot (H_t L^A)^{1-\theta}] + \mu(t) \cdot [F(K^s(t), A^s(t), \overline{L} - L^m) - C^s(t)] \tag{SP}$$

together with the initial conditions $K(0) > 0$, $H(0) > 0$. The objective function in this program is continuous and strictly concave. The constraint set forms a strictly convex set in which guarantees the household has a unique solution. $C^m(t)$, $C^s(t)$ and H_t are control variables, $K^m(t)$ and $A(t)$ are state variables. $\lambda_m(t)$ and $\lambda_A(t)$ are Hamilton multipliers, $\mu(t)$ is Lagrangian multiplier. The first order conditions are

$$\frac{\partial H^e}{\partial C^m(t)} = U'(C^m(t)) - \lambda_m(t) = 0 \tag{12}$$

$$\frac{\partial H^e}{\partial C^s(t)} = U'(C^s(t)) - \mu(t) = 0 \tag{13}$$

$$\frac{\partial H^e}{\partial H(t)} = U'_{H(t)} + \lambda_A(t) \cdot (1-\theta) \cdot (\frac{A(t)}{H(t) \cdot L^A})^\theta = 0 \tag{14}$$

Euler conditions are

$$-\dot{\lambda}_m(t) = \lambda_m(t) \cdot [r - \delta] + \mu \cdot r \cdot n - \rho \cdot \lambda_m(t) \tag{15}$$

$$-\dot{\lambda}_A(t) = \lambda_A(t)\cdot\theta\cdot(\frac{H_t L^A}{A(t)})^{1-\theta} + \mu(t)\cdot[F^s_{A^s(t)}{}' \cdot \frac{dA^s(t)}{dA(t)}] - \rho\cdot\lambda_A(t) \qquad (16)$$

two transversality conditions are

$$\lambda_m(\infty) = 0 \qquad (17) \qquad\qquad \lambda_A(\infty) = 0 \qquad (18)$$

Proposition 1. Outputs and capitals in both manufacturing and service section share the same growth rate as consumption and technology in the economy.

$$g_{Y^m} = g_{Y^s} = g_{K_m} = g_{K_s} = g_{A_m} = g_{A_s} = g_{C^m} = g \qquad (19)$$

(Proof. See Appendix A)

The Proposition 1 implies a stable economic industrial structure existing in steady state. Our results are different from these of Kongsamut, Rebelo and Xie (2001), Acemoglu and Guerrieri (2008). In our analysis, the economy runs in balance growth path unlike the unbalance paths of Kongsamut, Rebelo and Xie (2001), Acemoglu and Guerrieri (2008). According to first order conditions and Euler conditions. We can obtain the ratio of manufacturing consumption and manufacturing output expressed by parameters *m*.

$$\frac{C^m(t)}{Y^m(t)} = \frac{\alpha}{r}(r - g - \delta) = m \qquad (20)$$

The steady growth rate has two expressions as follows

$$g = \frac{r - \delta + rn\cdot(\frac{m}{n})^{1-\beta} - \rho}{\sigma} \qquad (21)$$

$$g = \frac{\rho[(\frac{m}{n})^{\beta} + 1]}{(\theta - \sigma)\cdot[(\frac{m}{n})^{\beta} + 1] + (1-\alpha)(1-\theta)} \qquad (22)$$

(All steady state can be found in appendix B)

Now we obtain 3 nonlinear equations expressed by 7 parameters, ρ, n, β, θ, α, σ and θ, and the 7 parameters can be reduced to 5 parameters by equation (10) and $\sigma = 1 - \beta$ (see appendix A). There are 3 variables g, r and m in the nonlinear system, we can find the growth rate is endogenous in the model as well as the interest rate. To solve local values of g and r, m, we should give appropriate values to parameters and initial values of g, r and m in the nonlinear system solution.

Equation (3) can also be expressed by $\dot{A}(t)/A(t) = A(t)^{\theta-1}[H(t)L^A]^{1-\theta} = g$. The production functions have another expression substituting $A(t)$ with $H(t)$.

$$Y^i = g^{\frac{1-\alpha}{\theta-1}} \cdot K^i(t)^\alpha \cdot [H(t) \cdot L^i]^{1-\alpha} \qquad i = m, s \tag{23}$$

In our model, the production function with endogenous technology as Romer (1990) can be expressed by the production function with human capital as Lucas (1988, 2009), Jones (1995a), Barro, Mankiw and Sala-I-Martin (1995), Segerstrom (1998), Jones (2002), Buera and Kaboski (2008). Because $K(t)/H(t)$ is constant, the production function can also be seen as a AK function. With the competitive capital market assumption and equation (23), the productivities in both sections are

$$\frac{Y^m(t)}{H_m \cdot L^m} = \frac{Y^s(t)}{H_s \cdot L^s} = \frac{(\alpha/r)^{\frac{\alpha}{1-\alpha}}}{g^{1/(1-\theta)}} \tag{24}$$

In the benchmark model, productivities with human capital in both sections are the same. In general calculation of productivity, the productivity is defined as $Y^i(t)/L^i$, $i = m, s$, the labors in the expression includes all types of labors, such as simple labor and complex labor, and the complex labor should be augmented by $A(t)$ or $H(t)$, so productivities being expressed by $Y^i(t)/(H(t) \cdot L^i)$ is more reasonable. In real economy, the sectional productivities are usually different especially in China. During years of 1991-2003, only in 3 years, 1991, 1992 and 1993, the sectional productivity ratios are near one, the rest years' sectional productivity ratios are far away from one. The possible explanation for the difference of ratios is government industrial policy. The China governments, especially states governments, have different preference in different development periods. Previously, states' governments preferred to manufacturing industry for more output on purpose of local leaders' promotion, they gave their desiring firms subsidies such as tax exemption and land fee reduction. Recently, States' governments prefer to service industry to attract more employment on purpose of urbanization. In next section, we will analyze how the industry policy of the government, mainly embodied in fiscal policy, affects the structure of the economy.

III. Extensions

The model presented above is one ideal model. In real economy, the government, such as the China's local government, sometime wants to development one of industries. In 1990-2010, China's government incentives the manufacture section by taxation preferential treatment and subsidies for the sake of faster economic growth. Recently, China's government encourages the service section's growth for the sake of employment and urbanization. In this part, we analyze how government's fiscal policy changes steady states. We in here give two extensions. The first one is that the fiscal policy prefers to acquire the tax from the manufacturing section and transfer the tax to the service section. The second one is that taxation policy prefers to acquire the tax from the service section and transfer the tax to the manufacturing section. The differential fiscal policies lead steady states of economy to change comparing with those of the bench model in section II.

A. Tax on manufacturing section and transferring to service section

In this section, we assume that the fiscal authority has complete differential preference. In order to make the tax clear, the fiscal authority collects tax only in the manufacturing section, and transfers the levied tax to the service section as subsidies. Both sections maximize their profit functions under this situation. The fiscal authority levies τ_K and τ_{AL} to every unit of capital's output and labor-augment technology's output respectively in the manufacturing section. The first order conditions of the manufacturing section are

$$\alpha \cdot Y^m(t) = (1+\tau_K) \cdot r \cdot K^m(t) \tag{25}$$

$$(1-\alpha) \cdot Y^m(t) = (1+\tau_{AL}) \cdot P_A \cdot A^m(t) \tag{26}$$

we obtain

$$P_A \cdot A^m(t) = \frac{1-\alpha}{\alpha} \cdot \frac{1+\tau_K}{1+\tau_{AL}} \cdot r \cdot K^m(t) \tag{27}$$

The taxation to the stock of the capital and technology in the manufacturing section can also be thought as taxation to the aggregate output of manufacture section as follows:

$$T = \tau_K \cdot r \cdot K^m(t) + \tau_{AL} \cdot P_A \cdot A^m(t) = \tau \cdot Y^m(t) \tag{28}$$

combining (27) into (28), we obtain the flat taxation rate of the aggregate manufacturing output, τ is

$$\tau = \tau_K \cdot \frac{\alpha}{1+\tau_K} + \tau_{AL} \cdot \frac{1-\alpha}{1+\tau_{AL}} \tag{29}$$

Because the tax levied from the manufacturing section will be transferred to the service section by the fiscal authority, the service section uses the transferred stock of tax as capitals and invests into its own production. The optimal behavior of two sections and the competitive capital market assumption satisfy two conditions: (I) $P_A \cdot A^m(t) + \tau Y^m(t) = r \cdot K^s(t)$, (II) $P_A \cdot A^m(t) = (1-\alpha)Y^m(t)$, thus we can obtain

$$(\frac{1-\alpha}{1+\tau_{AL}} + \tau) \cdot Y^m(t) = rn'K^m(t) \tag{30}$$

combine (30) into (25), we obtain a new structural capital(output) ratio, n', between the service section and the manufacturing section,

$$n' = \frac{(1+\tau_K) \cdot (\frac{1-\alpha}{1+\tau_{AL}} + \tau)}{\alpha} = \frac{1-\alpha+\tau_K}{\alpha} \tag{31}$$

Capitals allocation in both sections changes on account of taxation. In comparative static analyses,

$$\frac{\partial n'}{\partial \tau_K} > 0 \quad , \frac{\partial n'}{\partial \tau_{AL}} > 0 \text{ and } \frac{\partial n'}{\partial \tau_K} > \frac{\partial n'}{\partial \tau_{AL}}$$

Tax on capitals in the manufacturing section has more influences than that of the technology-augment labor in the section. In addition, because of the competitive capital market and profit maximization, the ratio of manufacturing section's output to service section's is

$$\frac{Y^m(t)}{Y^s(t)} = \frac{\alpha}{1-\alpha+\tau_K} \tag{32}$$

The differential taxation on manufacturing section obviously improves the service section's proportion in the aggregate output compared with the output proportion without differential taxation and tax transferring. The transition of capitals is

$$\dot{K}^m(t) = r \cdot K^m(t) - C^m(t) - \delta \cdot K^m(t) \tag{33}$$

As analysis above, the steady growth rates of sections' output and capital, consumption and technology are unique. Using the steady growth rates and Hamilton function including the service section constraint (11) and (33), we obtain the Proposition 2.

Proposition 2. Compared to the steady growth rate and the interest rate in the economy without differential fiscal policy, the steady growth rate and the interest rate in the economy with differential fiscal policy are the same. The proportion of manufacture in the whole economy will decrease.

(Proof in appendix C)

The steady growth rate has two expressions as same as that of the benchmark model.

$$g = \frac{r - \delta + rn^{'} \cdot (\frac{m}{n^{'}})^{1-\beta} - \rho}{\sigma} \tag{34}$$

$$g = \frac{\rho[(\frac{m}{n^{'}})^{\beta} + 1]}{(\theta - \sigma) \cdot [(\frac{m}{n^{'}})^{\beta} + 1] + (1-\alpha)(1-\theta)} \tag{35}$$

According to equations of (34) and (35), the effect of fiscal policy does not appear directly in the steady state growth rate, and the fiscal policy affects indirectly through the industrial proportion, $n^{'}$. Firms face the exogenous interest rate in the competitive capital market, and the dynamic motion equation of capitals for the manufacture firms and of technology also unchangeable, so the solution for steady state of growth rate does not change in equation (34). The question is how industrial structure $n^{'}$ does change the steady state of growth rate. If the effect of fiscal policy is slight, or to say, when the τ_K is relatively small, the solution of the steady state growth rate in nonlinear system will deviate very little, which makes the steady state of the growth rate won't change more through the transformation of equations of (34) and (35). The ratio of the manufacturing consumption and the manufacturing output is

$$\frac{C^m(t)}{Y^m(t)} = \frac{\alpha}{(1+\tau_K) \cdot r} \cdot (r - g - \delta) = m^{'} \tag{36}$$

The rate of capital taxation, τ_K, appears in the new expression of consumption and output ratio on behalf of the effect of fiscal policy to changes of the consumption. Based on the analysis above, the fiscal authority's slight behavior generally does not change the steady state of growth rate, and just only changes the economic structure and the aggregate manufacturing output allocation to the consumption side. The interesting economic implication emerges that if the economic authority wants to affect the growth rate through the industrial structure transformation by the fiscal policy, the consequence of the policy is always useless. The productivities in both sections are

$$\frac{Y^s(t)}{H_{st} \cdot L^s} = \frac{(\alpha / r)^{\frac{\alpha}{1-\alpha}}}{g^{1/(1-\theta)}} \tag{37}$$

$$\frac{Y^m(t)}{H^m(t)\cdot L^m} = \frac{A^s(t)}{A^m(t)}\cdot\frac{Y^s(t)}{H^s(t)\cdot L^s} = \frac{(\alpha/r)^{\frac{\alpha}{1-\alpha}}}{g^{1/(1-\theta)}} \tag{38}$$

Compared to the benchmark model, the productivity in the manufacture section decreases, and the service section's productivity does not change. The nature of the change of productivities rises from two channels: the competitive capital market and behavior of fiscal authority. The first channel is that the same price of capitals in production of both sections. The second one is that the fiscal authority levies τ_K for every unit of capital income of the manufacture firms, which increases τ_K in the cost of every unit of the capital in manufacturing production. The different results of maximization profits of firms are that the manufacture firms' marginal output of capitals is $(1+\tau_K)\cdot r$, and service firms' capital marginal output is r.

B. Tax on service section and transferring to manufacturing section

Fiscal authority can also choose tax-fiscal policy to increase the manufacturing section's proportion, as China's government did during 1990-2005. For convenience, we also assume the taxation policies of fiscal authority completely prefers to the manufacturing output, so fiscal authority collects tax from the service section, and transfers the stock of levied tax to the manufacturing section as capitals. Expressions of tax rate of capital and technology-augment labor are the same as above. The service section maximizes its profits under the taxation policy. The first order conditions of service section are

$$\alpha\cdot Y^s(t) = (1+\tau_K)\cdot r\cdot K^s(t) \tag{39}$$

$$(1-\alpha)\cdot Y^s(t) = \tau_{AL}\cdot P_A\cdot A^s(t) \tag{40}$$

Define the flat tax rate to output is τ which has the same expression as (29). Combining (39) and (40), we obtain

$$P_A\cdot A^s(t) = \frac{1-\alpha}{\alpha}\cdot\frac{1+\tau_K}{\tau_{AL}}\cdot r\cdot K^s(t) \tag{41}$$

Because the fiscal authority transfers tax levied from the service section to the manufacturing section, the total tax is $\tau\cdot Y^m(t)$ which equals to

$$\tau_{AL}\cdot\frac{1-\alpha}{\alpha}\cdot\frac{1+\tau_K}{1+\tau_{AL}}\cdot rnK^m(t)$$

Consequently, the manufacturing section's maximization problem is

$$Max(K^m(t))^{\alpha}(A^m(t)L^m)^{1-\alpha}+[\tau_K\cdot r\cdot n''\cdot K^m(t)+\tau_{AL}\cdot\frac{1-\alpha}{\alpha}\cdot\frac{1+\tau_K}{\tau_{AL}}\cdot rn''K^m(t)]-rK^m(t)-P_A\cdot A^m(t) \quad (42)$$

The first order condition is

$$\alpha\frac{Y^m(t)}{K^m(t)}+(\tau_K+\tau_{AL}\cdot\frac{1-\alpha}{\alpha}\cdot\frac{1+\tau_K}{\tau_{AL}})\cdot r\cdot n''=r \quad (43)$$

The relationship of exchange between both sections satisfies

$$(1-\alpha)\cdot Y^m(t)=n''\cdot r\cdot K^m(t)\cdot(1+\tau_K) \quad (44)$$

thus we can obtain the capital proportion in both sections,

$$n''=\frac{\alpha(1-\alpha)}{\tau_K\cdot(\alpha^2-\alpha+1)+2\alpha^2-2\alpha+1} \quad (45)$$

Capital allocation in both sections changes on account of taxation. In comparative static analyses,

$$\frac{\partial n''}{\partial\tau_K}<0 \quad , \quad \frac{\partial n''}{\partial\tau_{AL}}<0\text{, and }\frac{\partial n''}{\partial\tau_K}<\frac{\partial n''}{\partial\tau_{AL}}$$

Tax on capitals in the service section has more influences than that of the technology-augment labor in that section. In addition, based on (39) and (44), we can obtain

$$\frac{Y^m(t)}{Y^s(t)}=\frac{\alpha}{1-\alpha} \quad (46)$$

$$A^m(t)=(\frac{\alpha n''}{1-\alpha})^{\frac{\alpha}{1-\alpha}}A^s(t) \quad (47)$$

Because of transfer of tax, the manufacturing section doesn't use so much technology as that in bench model. The transition of capital is

$$\dot{K}^m(t)=r(1+n''\tau_K+n''\tau_{AL}\cdot\frac{1-\alpha}{\alpha}\cdot\frac{1+\tau_K}{1+\tau_{AL}})\cdot K^m(t)-C^m(t)-\delta K^m(t) \quad (48)$$

And Hamilton function for the representative household is

$$H^e=U(C^m(t),C^s(t),H(t))+\lambda_m(t)[r(1+n''\cdot\tau_K+n''\cdot\tau_{AL}\cdot\frac{1-\alpha}{\alpha}\cdot\frac{1+\tau_K}{\tau_{AL}})\cdot K^m(t)-C^m(t)-\delta K^m(t)]$$

$$+\lambda_A(t)(A^{\theta}(t)(H(t)L^A)^{1-\theta})+\mu(t)[F(K^s(t),A^s(t),\overline{L}-L^m-L^A)-C^s(t)] \quad (49)$$

The household optimizes $C^m(t)$, $C^s(t)$, $H(t)$ as control variables and $K^m(t)$, $A(t)$ as state variables in Hamilton function. We obtain the Proposition 3 as well as the explicit growth rate, the interest rate and the manufacturing consumption to the output ratio expressed by coefficients.

Proposition 3. The steady growth rate in the economy with differential taxation is the same as that of the economy without differential taxation. And the interest rate in the economy with taxation is higher than interest rate without taxation.

(Proof in appendix D)

The steady growth rate has two expressions as the analysis above

$$g=\frac{1}{\sigma}[r(1+n''\cdot\frac{1}{\alpha}\cdot\tau_K+n''\cdot\frac{1-\alpha}{\alpha})-\delta+(1+\tau_K)\cdot rn''\cdot(\frac{m''}{n''})^{1-\beta}-\rho] \tag{50}$$

$$g=\frac{\rho[(\frac{m''}{n''})^{\beta}+1]}{(\theta-\sigma)\cdot[(\frac{m''}{n''})^{\beta}+1]+(1-\alpha)(1-\theta)} \tag{51}$$

The ratio of manufacturing consumption to manufacturing output is

$$m''=\frac{1-\alpha}{(1+\tau_K)n''r}[r(1+n''\cdot\frac{1}{\alpha}\cdot\tau_K+n''\cdot\frac{1-\alpha}{\alpha})-g-\delta] \tag{52}$$

The productivities in both sections are

$$\frac{Y^s(t)}{H_{st}\cdot L^s}=\frac{[\frac{\alpha}{r(1+\tau_K)}]^{\frac{\alpha}{1-\alpha}}}{g^{1/(1-\theta)}} \tag{53}$$

$$\frac{Y^m(t)}{H^m(t)\cdot L^m}=\frac{A^s(t)}{A^m(t)}\cdot\frac{Y^s(t)}{H^s(t)\cdot L^s}=\frac{[(1-\alpha)/n''r]^{\frac{\alpha}{1-\alpha}}}{g^{1/(1-\theta)}} \tag{54}$$

IV. Calibration

In this section, we undertake the benchmark model and extension models to calibrate the United States and China's situations to investigate whether the steady states obtained by our models are consistent with the data. In the benchmark model, steady states are expressed by 5 parameters, α, ρ, δ, σ, and θ.In calibration, we need to choose the values of these parameters and 5 initial values $r(0)$, $g(0)$, $c(0)$, $i(0)$ and $m(0)$. We choose the annual discount rate, $\rho=0.02$, the annual depreciation rate, $\delta=0.04$. Other parameters are different on the basis of two countries.

A. China's parameters

1. The output elasticity of capital, α

We use the Error Correct Model to estimate the α for yearly data 1990-2009, and the data come from China Statistical Yearbook. The capital stock is estimated by the Sustainable Consolidation Method, and capital depreciation rate is 0.04. Technology-augment labor weight by education years and its depreciation is also 0.04. Thus we obtain $\alpha = 0.62$, and $\frac{1-\alpha}{\theta-1}Ln(g)$ is 3.62, in which g is annual growth rate per capita.

2. Technological output elasticity of stock of technology, θ

During 1990-2009, the annual average growth rate per capita in China is 9.2%, the highest growth rate is 12.8% in 1992, and the lowest growth rate is 2.3% in 1990. The datum of 1990 is very abnormal, because the political event happened in Beijing in the year of 1989, and the economy deviated the normal growth path greatly after next 2 years. Eliminating the datum of growth rate in the year of 1990, the lowest growth rate is 6.7% in 1999 and 6.8% in 1998. We put the average, the highest and lowest growth rate per capita of China into $\frac{1-\alpha}{\theta-1}Ln(g)$, and let $\alpha = 0.62$ to get the parameter θ. θ is relatively robust in China's situation. $\theta \in [0.72, 0.78]$ in China's growth zone. In calibration, we let θ is 0.75.

3. The coefficient of relative risk aversion, σ

The values of σ are diversified in the literatures. Because our explicit steady states are dependent on the real numerical solution of the nonlinear system, and steady states are sensible to selection of σ, we find when the value is in the range of $\sigma \in [0.60, 0.70]$, the steady states are reasonable.

4. Initial values

The benchmark of our model is a system of nonlinear equations with 5 equations, including variables $m(t)$, $r(t)$, $g(t)$, $i(t)$ (investment ratio)and $c(t)$ (consumption ratio). To solve the nonlinear system, we give initial values that $m(0) = 0.02$, $r(0) = 0.10$, $g(0) = 0.08$, $i(0) = 0.6$ and $c(0) = 0.4$ on the basis of China statistical yearbook.

B. United States' parameters

1. The output elasticity of capital, α

Because growth rate in the steady state is constant, the technology in the production function can be substituted by the human capital, *H*. And the production function can be written as $Y = g^{\frac{1-\alpha}{\theta-1}} \cdot K_t^{\alpha} \cdot (HL)_t^{1-\alpha}$. According to Mankiw, Romer and Weil (1992) estimated shares of 0.36 for physical capital stock, and shares of 0.14 for physical capital stock with human capital accumulation in production. In Barro, Mankiw, and Sala-i-Martin (1995), they used shares of 0.3 for physical capital stock, 0.5 for human capital, and 0.2 for labor which yield $\alpha = 0.3/0.8 = 0.375$. Acemoglu and Guerrieri (2008) get shares of 0.39 for physical capital stock. Lucas (1988, 1990) let the α be 0.25. And in our paper, we use $\alpha = 0.25$.

2. Technological output elasticity of stock of technology, θ

United States' θ is difficult to obtain alone. We have to use Mankiw, Romer and Weil (1992) result in OECD's production function with human capital accumulation. Mankiw et.al (1992) estimated the constant 8.71 which is equivalently to $\frac{0.37}{\theta-1}Ln(g)$. According to $\frac{0.37}{\theta-1}Ln(g) = 8.71$, when economic growth rate falls into $[0.02, 0.04]$, the $\theta \in [0.83, 0.86]$. And in our paper, we use the maximum value $\theta = 0.86$.

3. The coefficient of relative risk aversion, σ

We let σ be 0.7. The reason why we use this value is similar with that of the China.

4. Initial values

The benchmark of our model is a system of 5 nonlinear equations, including variables $m(t)$, $r(t)$, $g(t)$, $i(t)$ (investment ratio) and $c(t)$ (consumption ratio). To solve the nonlinear system, we give the initial values that $m(0) = 0.1$, $r(0) = 0.06$, $g(0) = 0.02$, $i(0) = 0.1$ and $c(0) = 0.7$, ($g(0) = 0.02$, The BEA data imply the United States economic growth rate is about 2.7% from 1978 to 2013. $r(0) = 0.06$ according to Shirller's data, the average real annual interest rate of United States is 6.25% during 1978-2012. $c(0) = 0.7$ is compatible with WDI data of the United States due to that during 1978-2013, the private average consumption ratio is about 64%, and the average consumption ratio is about 82% including the governmental consumption. $i(0) = 0.1$ (The WDI data shows the United States annual gross capital formation rate is 22.06% during year 1978-2013) which is approximate United States interest rate, growth rate and consumption ratio. We compute the steady states of all variables in our model and obtain the results as follows.

Table 1 United States' calibration of the benchmark model

r	g	c	i/y	n
6.75%	2.08%	75.62%	20.62%	3

$\alpha = 0.25, \rho = 0.02$, $\sigma = 0.70$, $\theta = 0.86$ and $\delta = 0.04$

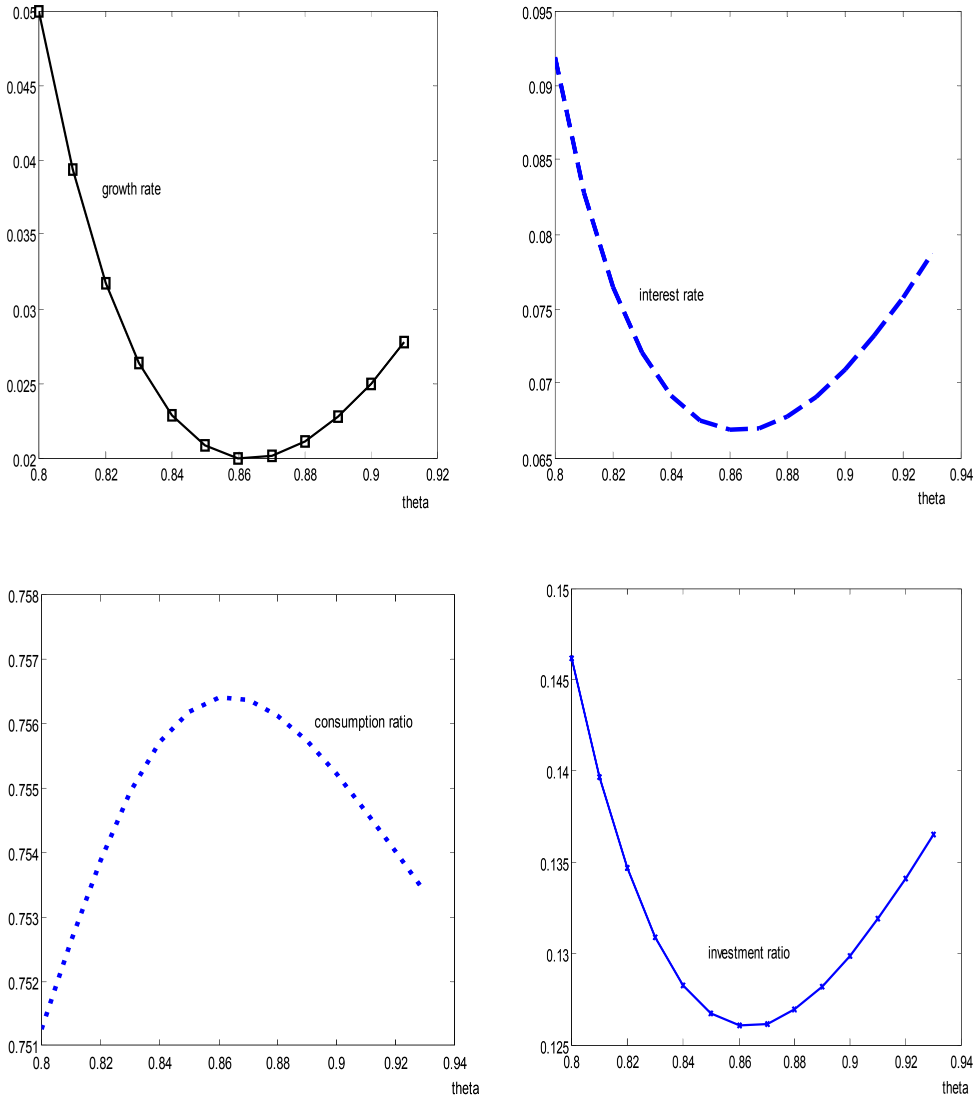

Figure 2-Behavior of *g, r, c* and *i/y*. In the benchmark calibration with $\alpha = 0.25$, $\rho = 0.02$, $\sigma = 0.70$ and $\delta = 0.04$.

Since the coefficient $\theta \in [0.83, 0.86]$, we enlarge θ's interval to $\theta \in [0.80, 0.92]$ and recalibrate the steady states of variables and figure 2 shows the results. The response of the sensibility of all variables does change more except consumption ratio. Another interesting result is that all variables chang un-monotonously with the change of θ, and all turning points is when $\theta \in [0.86, 0.87]$. When θ changes from 0.8 to 0.86, the growth rate, interest rate and investment

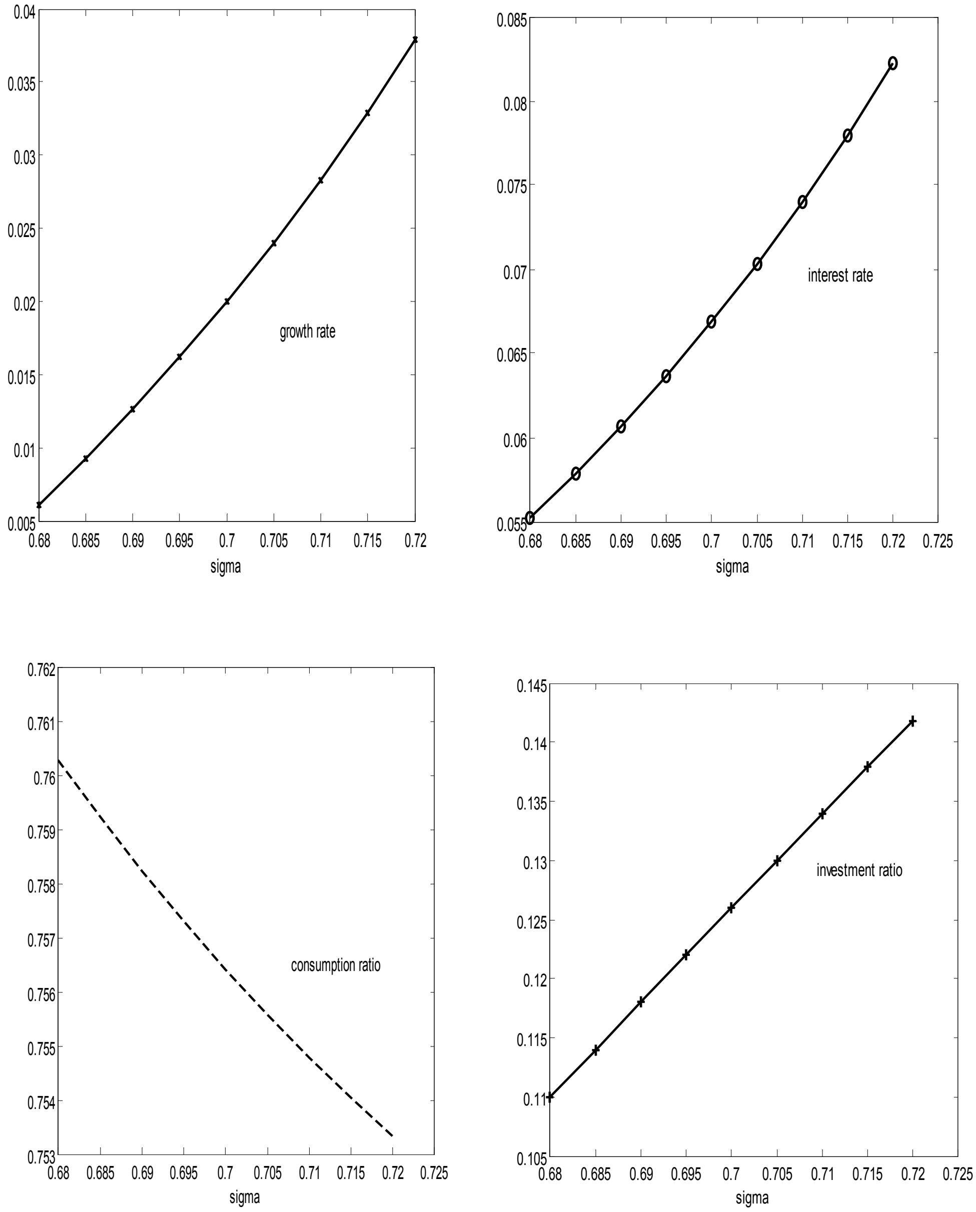

Figure 3-Behavior of *g, r, c* and *i/y*. In the benchmark calibration with $\alpha = 0.25$, $\rho = 0.02$, $\theta = 0.86$, $\sigma = 0.70$ and $\delta = 0.04$.

ratio decrease 3%, 2.5% and 2.0% respectively, and consumption ratio only increases 0.5%. On the other side, When θ changes from 0.86 to 0.92, the growth rate, interest rate and investment ratio increase 1.4%, 1.2% and 1.0% respectively, and consumption ratio only increases 0.2%.

The results for different values of $\sigma \in [0.68, 0.72]$ in figure 3 are different from that of θ . The responses to σ of the sensibility of all variables change except consumption ratio are also relatively large.

The United States' tax mainly comes from indirect tax income, such as tax income from personal income, the property and social security contribution, which dominate over 73% of total tax income since 1978, and the tax original from production only dominates less than 27% in the same period. On governmental spending side, the health care, pensions and defense are top 3 in government expenditures. The expenditure of the United States' federal and states' entering directly production is negligible. We use benchmark model to calibrate the economy of the United States.

Table 2 United States of tax on service section and transferring to manufacturing section

τ , τ_K	r	g	c	i/y	n
$\tau = 0$, $\tau_K = 0$	6.75%	2.08%	75.62%	20.62%	3.00
$\tau = 1\%$, $\tau_K = 0.4\%$	6.69%	2.00%	75.74%	20.54%	3.01
$\tau = 1\%$, $\tau_K = 0.5\%$	6.69%	2.00%	75.76%	20.52%	3.02
$\tau = 1\%$, $\tau_K = 0.8\%$	6.69%	2.00%	75.83%	20.46%	3.03
$\tau = 1\%$, $\tau_K = 1\%$	6.69%	2.00%	75.88%	20.42%	3.04
$\tau = 2\%$, $\tau_K = 1\%$	6.69%	2.00%	75.88%	20.42%	3.04
$\tau = 3\%$, $\tau_K = 2\%$	6.69%	2.00%	76.11%	20.23%	3.08
$\tau = 4\%$, $\tau_K = 3\%$	6.69%	2.00%	76.33%	20.04%	3.12

Table 3 United States of tax on manufacturing section and transferring to service section

τ , τ_K	r	g	c	i/y	n
$\tau = 0$, $\tau_K = 0$	6.75%	2.08%	75.62%	20.62%	3.00
$\tau = 1\%$, $\tau_K = 0.4\%$	6.59%	2.00%	73.63%	22.24%	2.67
$\tau = 1\%$, $\tau_K = 0.5\%$	6.59%	2.00%	73.61%	22.25%	2.67
$\tau = 1\%$, $\tau_K = 0.8\%$	10.48%	2.00%	73.27%	21.52%	2.67

$\tau = 1\%$, $\tau_K = 1\%$	10.48%	2.00%	73.17%	21.60%	2.65
$\tau = 2\%$, $\tau_K = 1\%$	10.36%	2.00%	71.30%	23.01%	2.40
$\tau = 3\%$, $\tau_K = 2\%$	10.19%	2.00%	69.36%	24.48%	2.16
$\tau = 4\%$, $\tau_K = 3\%$	10.27%	2.00%	67.52%	25.87%	1.97

The results of calibration of China are in table 4.

Table 4 China's calibration of the benchmark model

r	g	c	i/y	n
11.47%	8.17%	34.55%	51.63%	58.73

In the benchmark calibration with $\alpha = 0.63$, $\rho = 0.02$, $\sigma = 0.62$, $\theta = 0.73$ and $\delta = 0.04$.

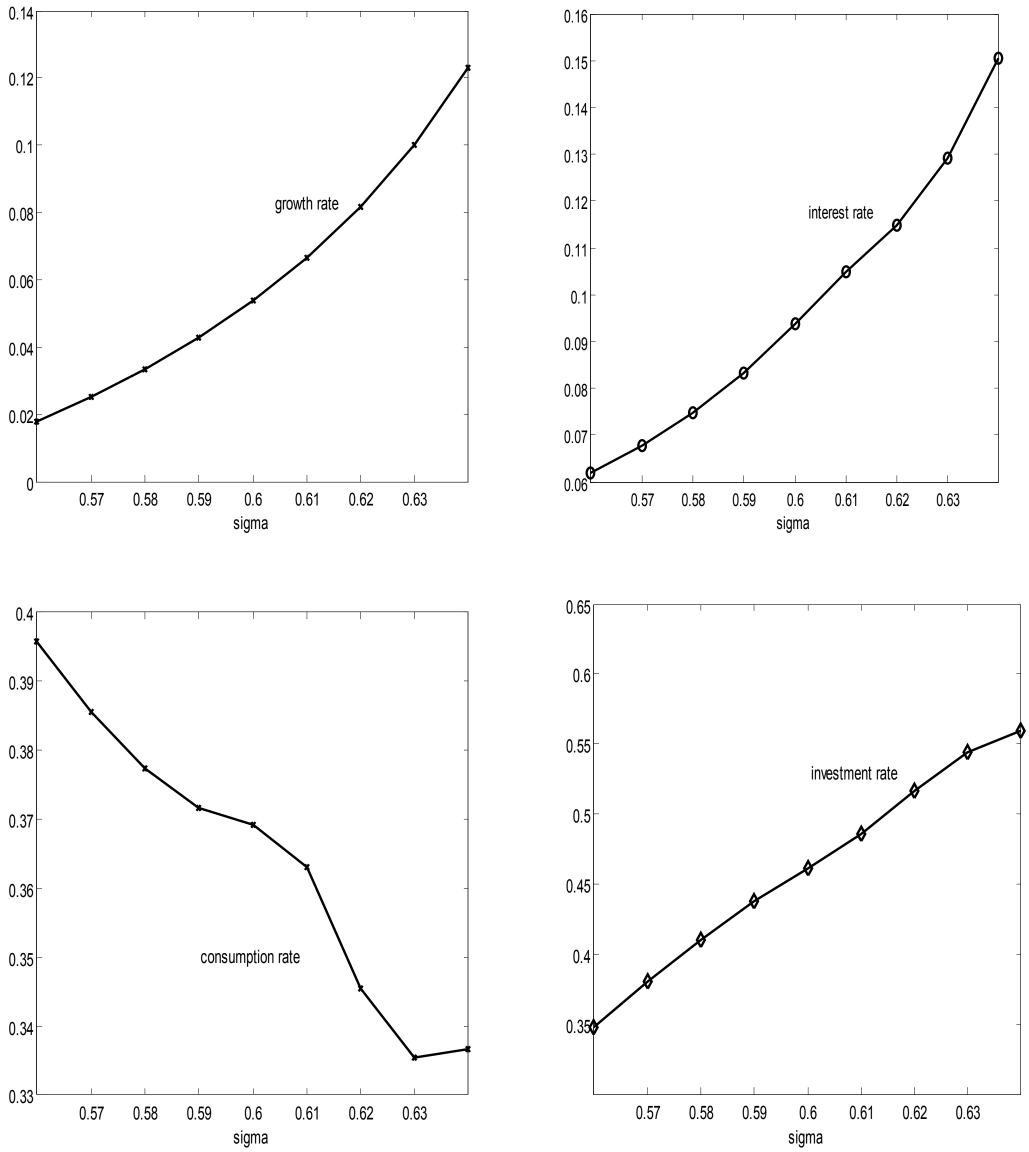

Figure 4-Behavior of *g, r, c* and *i/y*. In the benchmark calibration with $\alpha = 0.63$, $\rho = 0.02$, $\theta = 0.73$, $\sigma = 0.62$ and $\delta = 0.04$.

It's very difficult to get the China's fiscal transfer data between sections. In general, China's central and states' governments can practically adjust different tax rates to their preferring section. For example, in order to maintain manufacturing section's export, central government can increase export subsidies to manufacturing section, and because of lack of service export, the service section generally has no such much subsidies. Another example is that in order to increase one state's economic growth, local governments usually compete each other and decrease the land leasing fees to favorable firms to attract firms stay their development regions[4], in the same time, the service section need less lands than that of manufacturing section, and this service section usually gain less leasing fees from local governments. The fiscal statistic income data naturally don't include this kind of preferring transfer between sections, although the transfers appear widely across China. We here first assume the transfer to manufacturing section from service section and analyze the opposite transfer.

In the tax structure analysis, we consolidate the central and state's governments into one fiscal authority who can decide which section can own the fiscal transfer. Because the flat tax on the output and the tax on capitals affect the steady states in tax system, we only set τ and τ_K in analysis. In table 5, the first row is the outcomes about China in benchmark model, and other rows show results when fiscal authority transfer the fiscal subsidies to the manufacturing section, and the fiscal transfer is converted into tax levied from service section. Table 6 shows the results when the fiscal authority takes the opposite fiscal transfer.

Table 5 China of tax on service section and transferring to manufacturing section

τ , τ_K	r	g	c	i/y	n
$\tau = 0$, $\tau_K = 0$	11.47%	8.17%	34.55%	51.63%	58.73%
$\tau = 1\%$, $\tau_K = 0.4\%$	11.47%	8.17%	34.35%	51.73%	57.96%

4 The purpose of local governments setting up so called development regions is to attract firms. And local governments usually give their wanted firms benefits such as tax and the lands leasing fees reduction

$\tau = 1\%$, $\tau_K = 0.5\%$	11.47%	8.17%	34.33%	51.75%	57.90%
$\tau = 1\%$, $\tau_K = 0.8\%$	11.47%	8.17%	34.26%	51.80%	57.73%
$\tau = 1\%$, $\tau_K = 1\%$	11.45%	8.17%	34.21%	51.85%	57.61%
$\tau = 2\%$, $\tau_K = 1\%$	11.43%	8.17%	34.11%	51.87%	57.08%
$\tau = 3\%$, $\tau_K = 2\%$	11.41%	8.18%	33.77%	52.08%	56.01%
$\tau = 4\%$, $\tau_K = 3\%$	11.38%	8.18%	33.44%	52.29%	54.97%

Table 6 China of tax on manufacturing section and transferring to service section

τ, τ_K	r	g	c	i/y	n
$\tau = 0$, $\tau_K = 0$	11.47%	8.17%	34.55%	51.63%	58.73%
$\tau = 1\%$, $\tau_K = 0.4\%$	12.70%	9.73%	35.09%	53.01%	61.94%
$\tau = 1\%$, $\tau_K = 0.5\%$	12.70%	9.73%	35.16%	52.96%	62.10%
$\tau = 1\%$, $\tau_K = 0.8\%$	12.70%	9.73%	35.36%	52.79%	62.58%
$\tau = 1\%$, $\tau_K = 1\%$	12.70%	9.73%	35.49%	52.68%	62.90%
$\tau = 2\%$, $\tau_K = 1\%$	12.70%	9.73%	37.65%	52.68%	62.90%
$\tau = 3\%$, $\tau_K = 2\%$	12.70%	9.73%	36.15%	52.13%	64.52%
$\tau = 4\%$, $\tau_K = 3\%$	12.70%	9.73%	36.80%	51.60%	66.13%
$\tau = 10\%$, $\tau_K = 10\%$	12.70%	9.73%	40.97%	48.14%	77.42%

Table 4 reports the sensitivity of steady states of interest rate and the growth rate as well as the consumption rate, the investment-output rate, industrial structure. Effects on the interest rate and the growth rate indicated in the table 4 and 5 are negligible. Along with the increase of the taxation transfer to manufacturing section, the consumption-output ratio increases and investment-output ratio decreases, the manufacturing output to the aggregate output will increase according to the economic intuition. In table 5, the beginning of taxation transferring to the service section raises significantly the interest rate and the growth rate compared with the initial values. And continuously increases the taxation transferring to the service section, the interest rate and growth rate will keep constant. Consumption-output ratio increases and investment-output ratio decreases with increasing of the taxation transfer to the service section, and the service output to the aggregate output will increases.

Results of the calibration on the United States by the benchmark model we describe here are consistent with the United States' the growth rate, the interest rate, the ratio of consumption to output and of investment to output. In addition, sectional results from the benchmark model are also close to the China's situation. But the extension model is more applicable to China. We think the reason is that the United States is a relatively complete market oriented country, and all level governments rarely intervene directly the industrial development. On the contrary, China's all levels of governments have more intention to incentive the economic structure transformation, and it partly explains the economic structural and productivities' transformation.

V. Conclusion

This paper has studied how the industrial structure and the sectional productivity change when the fiscal authority employs different fiscal transfer in a dynamic heterogeneous-producer economy. The model was first solved analytically, and then quantitative analyses are performed. The fiscal subsidies to manufacturing section from the service section just increase the ratio of investment to and manufacturing proportion in aggregate production and decrease the ratio of consumption to output as well as lead to little changes of the interest rate and the growth rate. The fiscal subsidies to the service section from the manufacturing section have opposite effects on the ratio of consumption to output, of investment to output and manufacturing proportion in aggregate production and lead to more changes of the interest rate and the growth rate.

Simulating the model with empirical parameters leads to generally plausible results. For the benchmark specification, the simulating results are consistent with the United States' data. And the extension model partly explains the difference of

China’s industry productivities and economic structure transformation.

The model's analytical structure has some advantages. One is that it depicts the heterogeneous action between two sections to explain the industrial structure and section productivities. Another is that it introduces the fiscal action to generate alternative policy assessments and gives an account of the cross-country difference in industrial structure and productivities. Only using fiscal authority to explain the structure transformation and different industrial productivities is not sufficient, and there may be some other exogenous factors to affect the industrial transformation, and it is what we have to leave for future researches.

Appendix A

Proof of proposition 1.

Both sections are price takers and maximize their profits in the competitive capital markets, the growth rates of output and capital in both sections are given by

$$g_{Y^m(t)} = g_{Y^s(t)} = g_{K^m(t)} = g_{K^s(t)} = g_{A^m(t)} \tag{A1}$$

With equations of (1) and (2), the growth rates of technology in both sections are

$$\frac{Y^m(t)}{Y^s(t)} = \frac{A^m(t)L^m}{A^s(t)(L - L^m - L^A)} = \frac{K^m(t)}{K^s(t)} = \frac{1}{n} \tag{A2}$$

Combining the condition $Y^m(t)/Y^s(t) = L^m/(\overline{L} - L^m) = \alpha/(1-\alpha)$, the technology in both sections are given by

$$A^m(t) = A^s(t) \tag{A3}$$

Consequently, the growth rates of output, capital and technology in both sections are given by

$$g_{Y^m(t)} = g_{Y^s(t)} = g_{K^m(t)} = g_{A^m(t)} = g_{K^s(t)} = g_{A^s(t)} = g_{A(t)} = g \tag{A4}$$

According to the equation (7), we can obtain:

$$\frac{\dot{K}^m(t)}{K^m(t)} = r - \frac{C^m(t)}{K^m(t)} - \delta = g \tag{A5}$$

In terms of (A3), the ratio of consumption on manufacturing products and the capital of manufacturing sector is a constant, which means

$$g_{C^m(t)} = g_{K^m(t)} \tag{A6}$$

Hence,

$$g_{Y^m(t)} = g_{Y^s(t)} = g_{K^m(t)} = g_{A^m(t)} = g_{K^s(t)} = g_{A^s(t)} = g_{C^m(t)} = g \tag{19}$$

Appendix B

Proof of the steady state equilibrium.

According to the equation (8) and (A5), the ratio of manufacturing consumption and output is

$$\frac{C^m(t)}{Y^m(t)} = \frac{\alpha}{r}(r - g - \delta) = m \tag{B1}$$

According to the first order conditions of (12), (13), (A2) and (A3), we can get:

$$\frac{\dot{\lambda}_m(t)}{\lambda_m(t)} = \frac{\dot{\mu}(t)}{\mu(t)} = -\sigma g \tag{B2}$$

and $\sigma = 1 - \beta$, combining with (B2), the growth rate of the steady state as follows:

$$g = \frac{r - \delta + (\frac{m}{n})^{1-\beta} \cdot rn - \rho}{\sigma} \tag{B3}$$

According to the first order conditions of (13), (14) and the utility function, we can obtain:

$$\frac{U'(C^s(t))}{U'_{H(t)}} = \frac{\mu(t)}{-\lambda_A(t)(1-\theta)(\frac{A(t)}{H(t)L_A})^{\theta} \cdot L_A} = -\frac{H(t)}{[(\frac{m}{n})^{\beta} + 1] \cdot C^s(t)} \tag{B4}$$

and

$$\frac{\dot{\lambda}_A(t)}{\lambda_A(t)} = \frac{\dot{\mu}(t)}{\mu(t)} \tag{B5}$$

Combining with (A3) and differentiating the production functions of manufacturing and servicing sectors with respect to the technology, we have:

$$F^{s}_{A_s(t)}{}' \cdot \frac{dA^s(t)}{dA(t)} = (1-\alpha)\frac{Y^s(t)}{A^s(t)} \cdot \frac{dA^s(t)}{dA(t)} = (1-\alpha) \cdot \frac{Y^s(t)}{A(t)} \tag{B6}$$

Substituting (B6) into (16), growth rate of the steady state as follows

$$g = \frac{\rho[(\frac{m}{n})^{\beta} + 1]}{(\theta - \sigma) \cdot [(\frac{m}{n})^{\beta} + 1] + (1-\alpha)(1-\theta)} \tag{22}$$

Appendix C

Proof of proposition 2 is analogous to the Appendix B.

Appendix D

Proof of proposition 3 is analogous to the Appendix B

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