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Competition, Productivity Growth, and Structural Change

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Abstract

Extending the endogenous growth model proposed by Young (1998), we construct a two-sector growth model that explains the observed pattern of structural change. Unlike existing studies, we assume neither non-homothetic preferences nor exogenous differential in productivity growth among different sectors. Our key assumption is that any two goods produced by firms in a sector are closer substitutes than those produced by firms in other sectors, which gives rise to an endogenous differential in productivity growth among different sectors. When the two composite goods are poor substitutes, the share of employment gradually shifts from the sector with a low markup to that with a high markup. To test the validity of the prediction of our model, we also estimate industry-level total factor productivity (TFP) growth and markup using Japanese firm-level panel data. The empirical results show a negative correlation between estimated markup and long-term TFP growth, and a positive correlation between the growth of industrial labor input and markup, which supports our theoretical results. Finally, in contrast to the previous studies of structural change that consider competitive economies, we study the socially optimal allocation and characterize the optimal tax policies.

Keywords: Structural change, Endogenous technical change, Scale effects, Tax policies
JEL classification numbers: E2, H2, O3,

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1 Introduction

Recently, there is a renewed interest in the relationship between structural change and economic growth. Many authors construct models that show observed patterns of structural change; the shares of employment and nominal consumption expenditure shift from the technologically *progressive* sectors whose productivity growth rates are relatively high to the technologically *stagnant* sectors that exhibits relatively slow productivity growth and the relative prices of goods produced in the stagnant sectors are increasing.[1,2,3] In this respect, the recent studies provide us with more sophisticated frameworks than those examined by the earlier literature in the 1960s. Nevertheless, as pointed out by Buera and Kaboski (2009), the existing models are not completely consistent with observed pattern of the structural change and they often show empirically plausible behaviors only when a set of restrictive conditions is satisfied.

This paper presents a simple model of endogenous growth that may explain the observed pattern of the structural change. More specifically, extending the endogenous growth model proposed by Young (1998), we construct a two-sector growth model where in each sector, there are horizontally differentiated consumption goods that are combined into a composite good and hence there are two distinct composite goods. The labor productivity of different sectors are endogenously determined through investment decisions by individual firms and knowledge spillover sustains perpetual growth. The preferences of consumers are homothetic with respect to horizontally differentiated consumption goods. The production technologies of individual firms in different sectors are essentially identical, except for endogenously determined labor productivities. Our key assumption is that the elasticity of substitution between any two goods produced in a sector is higher than that in the other sector. In other words, any two goods produced by firms in a sector are closer substitute each other than those produced by firms in the other sector.

Difference in the elasticities of substitution endogenously gives rise to unbalanced productivity growth among different sectors. If any two goods produced in a sector are closer substitute each other than those in the other sector, goods in the former sector becomes more price elastic than those in the latter one. Firms in the former sector have stronger incentives to improve their labor productivity, which gives rise to unbalanced productivity growth endogenously in our model. The endogenous differential in productivity growth creates the pattern of structural change that is consistent with observation. When the two composite goods are poor substitute, the share of employment gradually shifts from progressive to stagnant sectors.

[1] We follow Baumol (1968) and call sectors that exhibit relatively fast (slow) productivity growth the *progressive* (*stagnant*) sectors. Traditionally, it has been thought that the productivity of services sector grows at slower rates. However, the recent studies reveal that there are substantial heterogeneity in the productivity growth rates among the services sector. For example, Jorgenson and Timmer (2011) show that productivity growth of distribution services had been more rapid than finance services. See Jorgenson and Gollop (1992), Baumol (2002), and Maroto and Cuadrado (2009) as well.

[2] The recent samples that study structural changes from the progressive sectors to the stagnant sectors include Pender (2003), Nordhaus (2006), Schettkat and Yocarini (2006), Maudos et al. (2008), Hartwig (2010), Jorgenson and Timmer (2011).

[3] Section 2 provides a short but more detail review of empirical facts on the structural change.

The share of nominal consumption expenditure for goods produced by the progressive sector decreases over time while that for goods produced by the stagnant sector gradually increases its share over time. The relative price of the composite good of the stagnant sector increases over time.

Importantly, our model provides an empirically testable prediction. Note that a high elasticity of substitution in a sector implies a low average markup in the sector. Then, the prediction of our model is summarized as: the average productivity growth is higher in the sector whose average markup is relatively low than in the sector whose average markup is high and that the shares of employment and nominal consumption expenditure gradually shift from the former to the latter sector. Using Japanese firm-level panel data, we test the prediction of our model. We estimate industry-level total factor productivity (TFP) growth and markup using Japanese firm-level panel data. The empirical results show a negative correlation between estimated markup and long-term TFP growth, and a positive correlation between the growth of industrial labor input and markup, which supports our theoretical results.

Finally, we study the socially optimal allocation and characterize the optimal tax policies. When the two composite goods are poor substitute, our results suggest the following four points: (i) The government should subsidize productivity improvements of the stagnant sector more than those of the progressive sector. (ii) The government should impose a higher entry fee for firms entering into the sector where the number of firms is growing. (iii) The production of firms faced with price less-elastic demand should be subsidized more. (iv) The government should impose a higher consumption taxes on the consumption of goods whose nominal expenditure share increases gradually.

In the foregoing literature, two approaches have been used to study structural change. The one is based on the demand-induced structural change due to the presence of non-homothetic preferences.[4] In most models of non-homothetic preferences, productivity growth differential among production sectors is not considered and the relative prices remain constant over time. The second approach is based on the assumption of *exogenously* given differential in productivity growth among production sectors. This approach is initiated by Baumol (1967) and recent studies include Ngai and Pissarides (2007) and Acemoglu and Guerrieri (2008).[5] Since the literature has mainly employed neoclassical (exogenous) growth models, they fail to exploit the recent development of endogenous growth theory and do not address factors that would generate productivity growth differential among production sectors. Furthermore, because existing studies based on both approaches mainly consider competitive economies without market failure, optimal allocation and policies have not been examined.

Recently, Guilló *et al.* (2011) construct a multisector overlapping generations model of endogenous technical change with the non-homothetic preference. The authors show that the non-homothetic preference generates labor inflow into the sectors with larger productivity

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[4]For example, Kongsamut *et al.* (2001) employ a Stone-Geary utility function to consider dynamics of sectoral labor reallocation. Foellmi and Zwimüller (2008) introduce a hierarchic utility function to obtain nonlinear Engel curves for the various products, which generates consumption cycles.

[5]Using U.S. date, İşcan (2010) calibrates the model that includes both exogenous differentials in productivity growth and non-homothetic preference. He shows that in the first half of the twentieth century, the contribution of effects of non-homothetic preference to the rising share of services in employment is significantly larger while effects of productivity growth differentials is larger in the second half of the twentieth century.

growth, which is inconsistent with the observed pattern of structural change.[6]

2 Facts on the Structural Change

Tables 1-4 show the basic empirical facts concerning the structural change that we try to address in this article. Table 1 shows value-added by different sectors as a percentage of GDP in 1980 and 2005 for five countries, and similarly for houses worked in Table 2. There are common trends in these five countries. The GDP shares of manufacturing sectors have been declining while the services sector have been increasing it share. However, more disaggregated view reveals heterogeneity within the services sector. The finance and business services gain their shares while the shares of distribution services have been fairly stable. The labor shares exhibit the similar trends.

[Tables 1 and 2]

In Tables 3 and 4, we show the growth rates of output prices and labor productivity, respectively. The output price and labor productivity of finance and business services tend to grow faster than those of distribution services. Generally, comparisons among Tables 1-4 show that (i) sectors with smaller (lager) productivity growth tend to have been gaining (losing) their GDP shares, the output prices in sectors with smaller productivity growth tend to have been growing faster than those in sectors in lager productivity growth, and (iii) more (less) labor tend to have been allocated to sectors with smaller (lager) productivity growth. These facts are well-documented in Pender (2003), Nordhaus (2006), Schettkat and Yocarini (2006), Maudos et al. (2008), Hartwig (2010), Jorgenson and Timmer (2011) as well.

[Tables 3 and 4]

3 The Model

Time is discrete and denoted by $t = 0, 1, 2, \cdots$. We consider an economy where there are two sectors indexed by $i = 1, 2$. In each sector, there is a continuum of differentiated varieties and the number of varieties in Sector i is equal to $n_i(t)$ in period t. Brand $j \in [0, n_i(t)]$ of good $i(= 1, 2)$ is produced by a monopolistically competitive firm. Before production of each brand in period t, individual firms must hire managers to invest in a production project in period $t-1$. Labor productivities of individual firms in period t increases with investment in period $t-1$. The average labor productivity in each sector can be improved through knowledge spillover across individual firms in each sector, as in Young (1998) and others.

[6] Guilló *et al.* (2011) also show that if cross-sector knowledge spillovers are introduced, their model can be reconciled with observation.

3.1 Households

The economy is populated by a continuum of identical households. The population size remains constant at one over time. As in Acemoglu et al. (2012) who study a two-sector endogenous growth model where the engine of growth is endogenous technological change as in ours, we assume that there are two types of labor; production labor and manager. Production labor is used only in production of each brand of goods while managers are used only in investment activities. Both types of labor are free mobile between Sectors 1 and 2. The representative household inelastically supplies L_P units of production labor and L_M units of managers in each period.

The utility of the representative household in period t is given by $U(t) = \sum_{s=t}^{\infty} \beta^{s-t} \ln C(s)$, where $\beta \in (0,\ 1)$ denotes the subjective discount factor. The subutility $C(t)$ is:

$$C(t) = \begin{cases} \left[\gamma C_1(t)^{\frac{\varepsilon-1}{\varepsilon}} + (1-\gamma)C_1(t)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}, & \text{if } \varepsilon \neq 1, \\ C_1(t)^{\gamma} C_2(t)^{1-\gamma}, & \text{if } \varepsilon = 1, \end{cases} \tag{1}$$

where $C_i(t)$ is the composite of good $i(=1,\ 2)$ that is specified below, $\varepsilon > 0$ is the elasticity of substitution between $C_1(t)$ and $C_2(t)$, and $\gamma \in (0, 1)$ represents the importance of good 1. Let us denote consumption of brand $j \in [0,\ n_i(t)]$ of good $i(=1,\ 2)$ at time t as $x_{i,j}(t)$. Following authors like Benassy (1996) and others, we specify the composite of good $i(=1,\ 2)$ as:

$$C_i(t) = n_i(t)^{\sigma_i + 1 - \frac{1}{\alpha_i}} \left[\int_0^{n_i(t)} x_{i,j}(t)^{\alpha_i} dj\right]^{\frac{1}{\alpha_i}}, \quad 0 < \alpha_i < 1, \quad \sigma_i \geq 0. \tag{2}$$

The parameter σ_i captures the taste for variety. As long as $\sigma_i > 0$, consumer prefers more varieties of good i. If $\sigma_i = (1-\alpha_i)/\alpha_i$, (2) corresponds to the standard consumption index of Dixits-Stiglitz (1977) type that is widely used in endogenous growth models.[7] The elasticity of substitution between any two brands of good i is equal to $\varepsilon_i \equiv 1/(1-\alpha_i)$ that is equal to the price elasticity of demand for any brands of good i. We assume $\alpha_1 \geq \alpha_2$, which means that any brands of good 1 tend to be closer substitutes for each other than those of good 2. To unveil the different roles of the elasticity of substitution, α_i, and taste for variety, σ_i, in generating the structural change, our model employs (2), rather than the standard consumption index of Dixits-Stiglitz (1977) type. It should be noted that preferences specified by (1) and (2) are homothetic with respect to $x_{i,j}(t)$.

The consumption expenditure for good $i(=1,\ 2)$ is:

$$E_i(t) = \int_0^{n_i(t)} p_{i,j}(t) x_{i,j}(t) dj, \tag{3}$$

where $p_{i,j}(t)$ is the price of brand j of good i in period t. The budget constraint is:

$$W(t) = [1 + r(t-1)]W(t-1) + w_P(t)L_P + w_M(t)L_M - E(t), \tag{4}$$

[7] See Grossman and Helpman (199), for example.

where $W(t)$ is asset holdings at the end of period t, $r(t-1)$ is the nominal interest rate between period $t-1$ and t, $w_P(t)$ ($w_M(t)$) is the wage rate for production labor (managers) and $E(t)(\equiv E_1(t)+E_2(t))$ is consumption expenditure. Because managers are skilled labor, $w_M(t)$ can be considered as the skilled wage.

We solve the optimization problem of the households in three steps. We first maximizes (2) subject to (3), which yields the following demand function for brand j of good i:

$$x_{i,j}(t) = \frac{E_i(t)p_{i,j}(t)^{-\frac{1}{1-\alpha_i}}}{\int_0^{n_i(t)} p_{i,j'}(t)^{-\frac{\alpha_i}{1-\alpha_i}} dj'}. \tag{5}$$

Apparently, if $\alpha_1 > \alpha_2$, the price elasticity of demand for any brands of good 1 is larger than that of good 2, which reflects the fact that any brands of good 1 are closer substitutes for each other than those of good 2. Substituting (5) into (2) yields $C_i(t) = E_i(t)/P_i(t)$, where $P_i(t) \equiv n_i(t)^{\frac{1-\alpha_i}{\alpha_i}-\sigma_i}\left[\int_0^{n_i(t)} p_{i,j}(t)^{-\frac{\alpha_i}{1-\alpha_i}} dj\right]^{-\frac{1-\alpha_i}{\alpha_i}}$ is the price index of the composite good i. The next step maximizes (1) subject to $E(t) = E_1(t) + E_2(t)$ and $C_i(t) = E_i(t)/P_i(t)$ to obtain:

$$\frac{C_2(t)}{C_1(t)} = \left(\frac{1-\gamma}{\gamma}\right)^{\varepsilon}\left(\frac{P_1(t)}{P_2(t)}\right)^{\varepsilon}, \quad \text{or} \quad \frac{E_2(t)}{E_1(t)} = \left(\frac{1-\gamma}{\gamma}\right)^{\varepsilon}\left(\frac{P_2(t)}{P_1(t)}\right)^{1-\varepsilon}. \tag{6}$$

Using $E(t) = P_1(t)C_1(t) + P_2(t)C_2(t)$ and the first equation of (6), we can rewrite (1) as $C(t) = E(t)/P(t)$, where $P(t) \equiv [\gamma^{\varepsilon}P_1(t)^{1-\varepsilon} + (1-\gamma)^{\varepsilon}P_2(t)^{1-\varepsilon}]^{\frac{1}{1-\varepsilon}}$ represents the price index for all consumption goods. We finally maximize $U(t)$ subject to (4) and $C(t) = E(t)/P(t)$, which results in:

$$\frac{E(t+1)}{E(t)} = \beta[1 + r(t)]. \tag{7}$$

3.2 Firms

Our modeling of firms is based on the endogenous growth model without scale effect proposed by Young (1998). Each brand of the two goods is produced by a monopolistically competitive firm. In period t, the number of firms in sector i is equal to $n_i(t)$. In period t, production of one unit of brand j of good i requires $1/b_{i,j}(t)$ units of production labor. The labor productivity $b_{i,j}(t)$ of individual firms determined by investment activities that will be mentioned soon later. The operating profits of firm j in Sector i in period t is equal to $\pi_{i,j}(t) = (p_{i,j}(t) - w_P(t)/b_{i,j}(t))x_{i,j}(t)$. We take production labor as the numeraire and set $w_P(t)$ equal to one.

In order to produce brand j of good i in period t, firm j must hire managers to invest in a production project in period $t-1$. As in Young (1998) and Acemoglu et al. (2012), the amount of managers required in investment activities is equal to $F(b_{i,j}(t), \bar{b}_{i,j}(t-1)) = a\left(b_{i,j}(t)/\bar{b}_{i,j}(t-1)\right)$, where $a(\cdot)$ is an increasing and convex function that takes positive values.[8] The investment cost in period $t-1$ of the individual firm j in Sector i in period t is then equal to $w_M(t-1)a(b_{i,j}(t)/\bar{b}_{i,j}(t-1))$. The presence of $\bar{b}_{i,j}(t-1)$ in $a(\cdot)$ reflects the intertemporal

[8] Young (1998) specifies $a(z) = fe^{\xi z}$ where $f > 0$ and $\xi > 0$ are parameters.

knowledge spillover that sustains growth. As in Young (1998), $\overline{b}_{i,j}(t-1)$ is equal to $b_{i,j}(t-1)$ if brand j of good i is produced in period $t-1$, and $\overline{b}_{i,j}(t-1)$ is equal to the average of $b_{i,j}(t-1)$ if brand j of good i is not produced in period $t-1$. For simplicity, we assume that all brands in Sector i(=1, 2) have the same initial productivities; $b_{i,j}(0) = b_{i,0}$ for all j where $b_{i,0} > 0$ (i =1, 2) is a positive constant.

Because firms must incur investment costs in each period and can not appropriate the intertemporal knowledge spillover, the planning horizon of each firm is only one period. Choosing $b_{i,j(t)}$ and $p_{i,j}(t)$, firm j in Secotr i that produces in period t maximizes:

$$\Pi_{i,j}(t-1) = \frac{\pi_{i,j}(t)}{1+r(t-1)} - a\left(\frac{b_{i,j}(t)}{\overline{b}_{i,j}(t-1)}\right) w_M(t-1). \tag{8}$$

Firms can freely enter each production sector and finance the costs of investment activities by borrowing from the household, as in Grossman and Helpman (1991).[9]

We solve the problem of individual firms in two steps. In the first step, firms chooses $p_{i,j}(t)$ so as to maximize the period t's operating profits $\pi_{i,j}(t)$. Next, given the choice of $p_{i,j}(t)$, firms chooses $b_{i,j}(t)$ so as to maximize $\Pi_{i,j}(t-1)$. The first step yields:

$$p_{i,j}(t) = \frac{1}{\alpha_i b_{i,j}(t)}. \tag{9}$$

The second step and the free entry condition implies:[10]

$$\frac{\alpha_i}{1-\alpha_i} = \frac{g_{i,j}(t)a'(g_{i,j}(t))}{a(g_{i,j}(t))}. \tag{10}$$

where $g_{i,j}(t) \equiv b_{i,j}(t)/\overline{b}_{i,j}(t-1)$ denotes the growth rate of the productivity of individual firm j in Sector i. From (10), all firms in Sector i choose the same level of $g_{i,j}(t)$ in every period. Hence, we omit index j and t from $g_{i,j}(t)$ and denote $g_i = g_{i,j}(t)$. Further, because of $b_{i,j}(0) = b_{i,0}$ for all i and j, we have $b_{i,j}(t) = b_{i,j'}(t) = b_{i,0} \times g_i{}^t$ for all j and j', which allows us to omit index j from $b_{i,j}(t)$. The second order condition ensures that the RHS of (10) must have a positive slope in equilibrium as shown in Figure 1.[11] Figure 1 presents the case where g_i is uniquely determined. With the help of Figure 1, we can prove the existence of g_i and can show that we have $g_1 > (=) g_2$ if $\alpha_1 > (=) \alpha_2$ holds.

[9]The asset holdings of the household, $W(t)$, represents lendings of the household to firms. In equilibrium, $W(t)$ is equal to $\sum_{i,j} a\left(b_{i,j}(t+1)/\overline{b}_{i,j}(t)\right) w_M(t)$.

[10]See Appendix A for the derivation of (10). Young (1998) derives the same condition as (10).

[11]If we use the first order condition (A.2), the second order condition can be written as:

$$\frac{a(g_i)}{b_i(t)\overline{b}_i(t-1)}\left[\left(\frac{\alpha_i}{1-\alpha_i}-1\right)\frac{a'(g_i)}{a(g_i)} - \frac{g_i a''(g_i)}{a(g_i)}\right] < 0.$$

Because $a(g_i)/(b_i(t)\overline{b}_i(t-1)) > 0$ holds, the second order condition ensures that the RHS of (10) has a positive slope in equilibrium. If we specify $a(z) = fe^{\xi z}$ where $f > 0$ and $\xi > 0$ are parameters as in Young (1998), we also confirm that the RHS of (10) has a positive slope.

[Figure 1]

Proposition 1
Suppose that $a'(1)/a(1)$ is strictly smaller than $\alpha_i/(1-\alpha_i)$ and $\lim_{z\to\infty} za'(z)/a(z)$ is strictly larger than $\alpha_i/(1-\alpha_i)$, and that $za'(z)/a(z)$ is a strictly increasing function of z. There exists a unique g_i that is larger than one. Further, if $\alpha_1 > (=)\alpha_2$ holds, $g_1 > (=)g_2$ holds.

In the following discussion, we assume the uniqueness of g_i. The reason for $g_1 > g_2$ under $\alpha_1 > \alpha_2$ is very intuitive. The inequality $\alpha_1 > \alpha_2$ means that demand for each brand of good 1 is more price elastic than that for good 2. Individual firms in Sector 1 have stronger incentives for improving their productivities than those in Sector 2. Then, we have $g_1 > g_2$.

Because $b_{i,j}(t) = b_i(t)(= b_{i,0}g_i{}^t)$ holds for all $j \in [0,\ n_i(t)]$, the price charged by firm j in Sector i, output and operating profits of firm j in Sector i can be written as:

$$p_{i,j}(t) = \frac{1}{\alpha_i b_i(t)} \equiv p_i(t), \tag{11a}$$

$$x_{i,j}(t) = \frac{E_i(t)}{n_i(t)p_i(t)} \equiv x_i(t), \tag{11b}$$

$$\pi_{i,j}(t) = \frac{(1-\alpha_i)E_i(t)}{n_i(t)} \equiv \pi_i(t). \tag{11c}$$

Firms in the same sector charge the same price, produce the same amounts and earn the same level of operating profits.

3.3 Labor Market

In period t, each firm in Sector i employs $a(g_i)$ units of managers for investment activities. Because $n_i(t+1)$ units of firms in Sector i invest in period t, the number of managers that are employed in Sector i in period t is:

$$L_{Mi}(t) = a(g_i)n_i(t+1) = \frac{(1-\alpha_i)E_i(t+1)}{(1+r(t))w_M(t)}, \tag{12}$$

where g_i is determined by (10). The second equality holds because of (11c) and (A.3). The production labor employed in Sector i in period t is:

$$L_{P,i}(t) = \frac{n_i(t)x_i(t)}{b_i(t)} = \alpha_i E_i(t). \tag{13}$$

The second equality holds because of (11a) and (11b). The equilibrium conditions for labor makets are:

$$L_P = L_{P1}(t) + L_{P2}(t), \quad \text{and} \quad L_M = L_{M1}(t) + L_{M2}(t). \tag{14}$$

4 Equilibrium and Structural Change

First, we express $E(t)$, $E_1(t)$, $E_2(t)$, $L_{P,i}(t)$, $L_{M,i}(t)$, $P_1(t)$, $P_2(t)$, $r(t)$ and $w_M(t)$ as functions of $n_i(t)$ and $b_i(t)$, and after then we derive $n_1(t)$ and $n_2(t)$. We begin to derive the relationship between $E_2(t)/E_1(t)$ and $n_2(t)/n_1(t)$. (12) indicates:

$$\frac{E_2(t)}{E_1(t)} = \frac{(1-\alpha_1)a(g_2)}{(1-\alpha_2)a(g_1)}\frac{n_2(t)}{n_1(t)}, \tag{15}$$

From (15) and $E(t) = E_1(t) + E_2(t)$, we have:

$$E_1(t) = \frac{1}{1+\frac{(1-\alpha_1)a(g_2)}{(1-\alpha_2)a(g_1)}\frac{n_2(t)}{n_1(t)}}E(t), \quad \text{and} \quad E_2(t) = \frac{\frac{(1-\alpha_1)a(g_2)}{(1-\alpha_2)a(g_1)}\frac{n_2(t)}{n_1(t)}}{1+\frac{(1-\alpha_1)a(g_2)}{(1-\alpha_2)a(g_1)}\frac{n_2(t)}{n_1(t)}}E(t), \tag{16}$$

where $n_i(t)$ is determined later. Substituting (16) and (13) into the first equation of (14) and then solving for $E(t)$, we obtain:

$$E(t) = \frac{\frac{a(g_1)}{1-\alpha_1} + \frac{a(g_2)}{1-\alpha_2}\frac{n_2(t)}{n_1(t)}}{\frac{\alpha_1 a(g_1)}{1-\alpha_1} + \frac{\alpha_2 a(g_2)}{1-\alpha_2}\frac{n_2(t)}{n_1(t)}}L_P. \tag{17}$$

Rather than the prices charged by individual firms, we are interested in the average price of each good that is represented by the price index of the composite i. Using (11a), we rewrite the price index of the composite good i as:

$$P_i(t) = \frac{1}{\alpha_i b_i(t) n_i(t)^{\sigma_i}}. \tag{18}$$

We are also interested in the average productivity of firms in each sector, rather than productivities of individual firms. As in Grossman and Helpman (1991) and others, we can consider $C_i(t)$ as the total production in Sector $i(=1, 2)$. Employing $L_{P,i}(t)$ unit of production labor, firms in Sector i produces $C_i(t)$ unit of good i as a whole. The average labor productivity of Sector i is equal to $B_i(t) \equiv C_i(t)/L_{P,i}(t)$. Because of $x_{i,j}(t) = x_i(t)$ (see (11b)), we have $C_i(t) = n_i(t)^{\sigma_i+1}x_i(t)$ in equilibrium. Using (13) and (18), we have:

$$B_i(t) \equiv \frac{C_i(t)}{L_{P,i}(t)} = b_i(t)n_i(t)^{\sigma_i} = \frac{1}{\alpha_i P_i(t)}. \tag{19}$$

The price index and the average productivity of Sector i depend on two factors; the productivity of individual firms $b_i(t)$ and the number of firms in Sector i. As the productivities of individual firms increase, the price index of the composite i decreases while the average productivity of Sector i increases. An increase in $n_i(t)$ has negative effects on $P_i(t)$ but has positive effects on $B_i(t)$.

Before deriving $n_i(t)$, we examine the relationships among endogenous variables. From the second equation of (6), we know that when $\varepsilon < 1$ holds, $E_2(t)/E_1(t)$ and $P_2(t)/P_1(t)$ move in the same direction, while $E_2(t)/E_1(t)$ moves in the opposite direction of $P_2(t)/P_1(t)$ when $\varepsilon > 1$ holds. Equations, (12), (13) and (15), show that the variables, $n_2(t)/n_1(t)$, $E_2(t)/E_1(t)$,

$L_{P,2}(t)/L_{P,1}(t)$ and $L_{M,2}(t)/L_{M,1}(t)$ all move in the same direction. Finally, (19) shows that $B_2(t)/B_1(t)$ moves in the opposite direction of $P_2(t)/P_1(t)$. We obtain the next lemma.

Lemma 1
(i) When $\varepsilon < (>) 1$ holds, $E_2(t)/E_1(t)$ and $P_2(t)/P_1(t)$ move in the same (opposite) direction.
(ii) $E_2(t)/E_1(t)$, $n_2(t)/n_1(t)$, $L_{P,2}(t)/L_{P,1}(t)$ and $L_{M,2}(t)/L_{M,1}(t)$ move in the same direction.
(iii) $P_2(t)/P_1(t)$ moves in the opposite direction of $B_2(t)/B_1(t)$.

This lemma is intuitive. (i) When the elasticity of substitution between goods 1 and 2 is large ($\varepsilon > 1$), consumers substitute good 1 for good 2 faced with increases in the relative price of good 2, $P_2(t)/P_1(t)$. Then, $E_2(t)/E_1(t)$ decreases. A small elasticity of substitution between goods 1 and 2 ($\varepsilon < 1$) indicates that for consumers, goods 1 and 2 are poor substitutes. As $P_2(t)/P_1(t)$ increases, the expenditure for good 2 increases relative to that for good 1. (ii) As the relative expenditure for good i increases, firms operating in Sector i can earn the relatively large operating profits and hence, more firms enter Sector i (see (15)). As a result, the more production labor and the more managers are allocated to Sector i. (iii) As Sector 1 improves the average productivity relative to Sector 2, the production costs of firms in Sector 1 reduce relative to those in Sector 2. Then, the price of good 1 decreases relative to that of good 2.

To obtain equilibrium, we proceed to the derivations of $n_1(t)$ and $n_2(t)$. After substituting (15) and (18) into the second equation of (6), we solve for $n_2(t)$ using $b_i(t) = b_{i,0}{g_i}^t$:

$$n_2(t) = \Psi \left(\frac{g_1}{g_2}\right)^{\eta \cdot t} n_1(t)^{\phi}, \tag{20}$$

where $\eta \equiv \frac{1-\varepsilon}{1+\sigma_2(1-\varepsilon)}$, $\phi \equiv \frac{1+\sigma_1(1-\varepsilon)}{1+\sigma_2(1-\varepsilon)}$ and $\Psi \equiv \left[\left(\frac{1-\gamma}{\gamma}\right)^{\varepsilon}\left(\frac{\alpha_1}{\alpha_2}\right)^{1-\varepsilon}\frac{1-\alpha_2}{1-\alpha_1}\frac{a(g_1)}{a(g_2)}\right]^{\frac{\eta}{1-\varepsilon}}\left(\frac{b_{1,0}}{b_{2,0}}\right)^{\eta} > 0$. Substituting (12) into $L_M = L_{M1}(t) + L_{M2}(t)$ yields:

$$n_2(t) = \frac{L_M - a(g_1)n_1(t)}{a(g_2)}. \tag{21}$$

Equations, (20) and (21), determine $n_1(t)$ and $n_2(t)$.

The RHS of (21) is a decreasing function of $n_1(t)$ that decreases from $L_M/a(g_2)$ to zero as $n_1(t)$ increases from zero to $L_M/a(g_1)$ as shown in Figure 2. When either $\varepsilon < \min\{(1+\sigma_1)/\sigma_1, (1+\sigma_2)/\sigma_2\}$ or $\varepsilon > \max\{(1+\sigma_1)/\sigma_1, (1+\sigma_2)/\sigma_2\}$ holds, ϕ becomes strictly positive. Given $t \geq 0$, the RHS of (20) becomes an increasing function of $n_1(t)$ that increases from zero to $+\infty$ as $n_1(t)$ increases from zero to $+\infty$, as shown in Figure 2. For any $t = 0, 1, 2, \cdots$, there exist a unique equilibrium and then we obtain the next proposition.

[Figure 2]

Proposition 2
When either $\varepsilon < \min\{(1+\sigma_1)/\sigma_1, (1+\sigma_2)/\sigma_2\}$ or $\varepsilon > \max\{(1+\sigma_1)/\sigma_1, (1+\sigma_2)/\sigma_2\}$ holds, there exist a unique pair of $n_1(t) > 0$ and $n_2(t) > 0$ for all $t \geq 0$.

In the following discussion, we assume $\varepsilon < \min\{(1+\sigma_1)/\sigma_1, (1+\sigma_2)\sigma_2\}$ or $\varepsilon > \max\{(1+\sigma_1)/\sigma_1, (1+\sigma_2)/\sigma_2\}$ to ensure the existence and uniqueness of equilibrium. Note that the RHS of (20) includes the time index $t(\geq 0)$ and then both $n_1(t)$ and $n_2(t)$ are functions of t. So, (20) and (21) provide the sequence of $\{n_1(t), n_2(t)\}_{t=0}^{\infty}$. Once the sequence of $\{n_1(t), n_2(t)\}_{t=0}^{\infty}$ is determined, the sequences of other endogenous variables we had already derived are also determined. In the remaining of this section, we examine the evolution of $n_1(t)$ and $n_2(t)$ and how the structural change occurs in our model.

When $\alpha_1 = \alpha_2$ holds, we have $g_1 = g_2$ and then (20) reduces to $n_2(t) = \Psi n_1(t)^{\phi}$ that is independent from t. Consequently, $n_1(t)$ and $n_2(t)$ become constant over time. When $\varepsilon = 1$ holds, we have $\eta = 0$ and then $n_1(t)$ and $n_2(t)$ again become constant over time. We next consider the case where $\alpha_1 > \alpha_2$ and $\varepsilon \neq 1$. The following two cases arise. From the definition of η, we have $\eta > 0$ when either $\varepsilon < 1$ or $\varepsilon > (1+\sigma_2)/\sigma_2$ holds. Because of $g_1/g_2 > 1$ under the assumption of $\alpha_1 > \alpha_2$ (see Proposition 1), the RHS of (20) rotates around the origin counterclockwise as t increases (see Figure 2 (a)). Then, $n_1(t)$ decreases and $n_2(t)$ increases over time and we have $\lim_{t\to\infty} n_1(t) = 0$ and $\lim_{t\to\infty} n_2(t) = L_M/a(g_2)$. When $1 < \varepsilon < (1+\sigma_2)/\sigma_2$ holds, in contrast, we have $\eta < 0$. As t increases, the RHS of (20) rotates around the origin clockwise, as shown in Figure 2 (b). Then, $n_1(t)$ increases and $n_2(t)$ decreases over time and we have $\lim_{t\to\infty} n_1(t) = L_M/a(g_1)$ and $\lim_{t\to\infty} n_2(t) = 0$. Because $\max\{(1+\sigma_1)/\sigma_1, (1+\sigma_2)/\sigma_2\} \geq (1+\sigma_2)/\sigma_2$ and $\min\{(1+\sigma_1)/\sigma_1, (1+\sigma_2)/\sigma_2\} \leq (1+\sigma_2)/\sigma_2$ hold, we obtain the next lemma.

Lemma 2
Suppose that either $\varepsilon < \min\{(1+\sigma_1)/\sigma_1, (1+\sigma_2)/\sigma_2\}$ or $\varepsilon > \max\{(1+\sigma_1)/\sigma_1, (1+\sigma_2)/\sigma_2\}$ holds and hence there exists a unique equilibrium.

1. *If either $\alpha_1 = \alpha_2$ or $\varepsilon = 1$ holds, $n_2(t)/n_1(t)$ remain constant over time.*

2. *If both $\alpha_1 > \alpha_2$ and $\varepsilon \neq 1$ hold,*

    (a) *when either $\varepsilon < 1$ or $\varepsilon > \max\{(1+\sigma_1)/\sigma_1, (1+\sigma_2)/\sigma_2\}$ holds, $n_2(t)/n_1(t)$ increases gradually over time. We have $\lim_{t\to\infty} n_1(t) = 0$ and $\lim_{t\to\infty} n_2(t) = L_M/a(g_2)$.*

    (b) *when $1 < \varepsilon < \min\{(1+\sigma_1)/\sigma_1, (1+\sigma_2)/\sigma_2\}$ holds, $n_2(t)/n_1(t)$ decreases gradually over time. We have $\lim_{t\to\infty} n_2(t) = L_M/a(g_1)$ and $\lim_{t\to\infty} n_2(t) = 0$.*

Lemma 2 shows that when both $\alpha_1 > \alpha_2$ and $\varepsilon \neq 1$ hold, either $n_1(t)$ or $n_2(t)$ tends to zero as $t \to \infty$. However, this does not mean that Sector 1 (2) does not produce anything because the economy approaches the limit of equilibrium only asymptotically. In fact, at all points in time, both sectors produce positive amounts. Combining Lemmas 1 and 2, we know how the economy evolves over time, as shown in the next proposition.

Proposition 3
Suppose that either $\varepsilon < \min\{(1+\sigma_1)/\sigma_1, (1+\sigma_2)/\sigma_2\}$ or $\varepsilon > \max\{(1+\sigma_1)/\sigma_1, (1+\sigma_2)/\sigma_2\}$ holds and then there exists a unique equilibrium.

1. *If either $\alpha_1 = \alpha_2$ or $\varepsilon = 1$ holds, $E_2(t)/E_1(t)$, $n_2(t)/n_1(t)$, $L_{P,2}(t)/L_{P,1}(t)$ and $L_{M,2}(t)/L_{M,1}(t)$ remain constant over time.*

2. *If we have both $\alpha_1 > \alpha_2$ and $\varepsilon \neq 1$, the followings hold.*

   (a) *When $\varepsilon < 1$ holds, $B_2(t)/B_1(t)$ decreases over time whereas $n_2(t)/n_1(t)$, $E_2(t)/E_1(t)$, $P_2(t)/P_1(t)$, $L_{P,2}(t)/L_{P,1}(t)$ and $L_{M,2}(t)/L_{M,1}(t)$ increase over time.*

   (b) *When $1 < \varepsilon < \min\{(1+\sigma_1)/\sigma_1, (1+\sigma_2)/\sigma_2\}(\leq (1+\sigma_2)/\sigma_2)$ holds, $n_2(t)/n_1(t)$, $B_2(t)/B_1(t)$, $E_2(t)/E_1(t)$, $L_{P,2}(t)/L_{P,1}(t)$ and $L_{M,2}(t)/L_{M,1}(t)$ decrease over time whereas $P_2(t)/P_1(t)$ increases over time.*

   (c) *When $\varepsilon > \max\{(1+\sigma_1)/\sigma_1, (1+\sigma_2)/\sigma_2\}(\geq (1+\sigma_2)/\sigma_2)$ holds, $n_2(t)/n_1(t)$, $B_2(t)/B_1(t)$, $E_2(t)/E_1(t)$, $L_{P,2}(t)/L_{P,1}(t)$ and $L_{M,2}(t)/L_{M,1}(t)$ increase over time whereas $P_2(t)/P_1(t)$ decreases over time.*

The conditions under which the structural change occurs require $\alpha_1 > \alpha_2$ and $\varepsilon \neq 1$. The difference in taste for variety, σ_i, is irrelevant to the structural change. When $\alpha_1 > \alpha_2$ and $\varepsilon \neq 1$ hold, three cases arise depending on the value of ε. Because empirically the most plausible results are obtained when the elasticity of substitution between goods 1 and 2 is relatively small ($\varepsilon < 1$), the following discussion focuses on $\varepsilon < 1$. In this case, the average productivity of Sector 1, $B_1(t)$, grows faster than that of Sector 2, $B_2(t)$. Sector 1 can be considered as the technologically *progressive* sector while Sector 2 is the technologically *stagnant* sector. The relative price of goods produced in the stagnant sector, $P_2(t)/P_1(t)$, increases over time. The employments shift from the progressive sector into the stagnant sector. The share of the nominal consumption expenditure for goods produced in the stagnant sector increases over time. Figure 3 shows a numerical example of the structural change in our model, assuming $a(z) = fe^{\xi \cdot z}$ as in Young (1998).

[Figure 3]

The intuition behind the structural change in our mode is simple. Because of the difference between g_1 and g_2 ($g_1 > g_2$) caused by the difference in α_1 and α_2, $b_1(t)/b_2(t)$ gradually increases over time, which has positive effects on $P_2(t)/P_1(t)$ (see (18)). When the elasticity of substitution between goods 1 and 2 is small ($\varepsilon < 1$) and hence goods 1 and 2 are poor substitutes for consumers, consumers gradually increase the expenditure for good 2 relative to that for good 1, $E_2(t)/E_1(t)$, as $P_2(t)/P_1(t)$ increases (see (6) and Lemma 1 (i)). Then, entries into Sector 2 are more stimulated than those into Sector 1, which has a positive effect on $n_2(t)/n_1(t)$ (see (15)). Because more and more firms operate in Sector 2, the more production labor and the more managers are allocated to Sector 2.

5 Empirical Evidence

Section 4 observed that when $\alpha_1 > \alpha_2$ and $\varepsilon < 1$ hold, our model produces the empirical observed pattern of the structural change. Our model provides the further insight. The inequality $\alpha_1 > \alpha_2$ implies that any brands of good 1 tend to be closer substitutes for each other than those of good 2 and hence the average markup in Sector 1 is smaller than that in Sector 2 (see (9)). Then, our model provides an empirically testable prediction that the average productivity growth is higher in the sector whose average markup is relatively high than in the sector whose average markup is low and that the shares of employment gradually shift from the former to the latter sectors. Using Japanese firm-level panel data, this section tests the prediction of our model.

5.1 Empirical Strategy

In order to test the abovementioned hypothesis, we first estimate industry-level markup and total factor productivity (TFP) growth and then investigate whether the two variables are negatively correlated. We also examine whether the shares of employments measured by labor hours and the number of employees shift from low-markup industries to high-mark industries. For our purpose, we utilize the method proposed by Krette (1999) and Kiyota (2010), who estimate markup and TFP simultaneously from plant- or firm-level micro data.

They assume that a firm j in industry i produces output Y using capital stock X^K, intermediate goods X^M, and labor X^L in year t, with a production function $Y_{i,j,t} = A_{i,j,t}F(X^K_{i,j,t}, X^L_{i,j,t}, X^M_{i,j,t})$, where $A_{i,j,t}$ stands for firm-level total factor productivity. Utilizing the internal point theorem, they log-linearize the output function to obtain:

$$y_{i,j,t} = a_{i,j,t} + \beta^K_{i,j,t}x^K_{i,j,t} + \beta^L_{i,j,t}x^L_{i,j,t} + \beta^M_{i,j,t}x^M_{i,j,t}, \tag{22}$$

where lower-case letters indicate the log deviations from the reference firm ($j = r$) in base year ($t = 0$).[12] For example, $y_{i,j,t}$ stands for $\ln(Y_{i,j,t}) - \ln(Y_{r,j,0})$. $\beta^K_{i,j,t}$, $\beta^L_{i,j,t}$, and $\beta^M_{i,j,t}$ are defined as:

$$\beta^h_{i,j,t} = \left(\frac{X^h_{i,j,t}}{Y_{i,j,t}} \frac{\partial Y_{i,j,t}}{\partial X^h_{i,j,t}} \right)_{X^h_{i,j,t} = \tilde{X}^h_{i,j,t}}, \tag{23}$$

where $h = K, L, M$, and $\tilde{X}^h_{i,j,t}$ is an internal point between the inputs of firm j in year t and those of reference firm. In order to rewrite $\beta^K_{i,j,t}$ $\beta^L_{i,j,t}$ and $\beta^M_{i,j,t}$, Klette (1999) and Kiyota (2010) focus on the profit maximization conditions of firms with market power. Denoting output price and factor prices that firm j faces in year t as $p_{i,j,t}$, $p^K_{i,j,t}$, $p^L_{i,j,t}$ and $p^M_{i,j,t}$, we obtain the following expression.

$$\frac{\partial Y_{i,j,t}}{\partial X^h_{i,j,t}} = A_{i,j,t} \frac{p^h_{i,j,t}}{(1 - \xi^{-1}_{i,j,t})p_{i,j,t}}, \tag{24}$$

Where $\xi_{i,j,t}$ is the price elasticity of demand, and the term $(1-\xi^{-1}_{i,j,t})^{-1}$ stands for markup ($\mu_{i,j,t}$). Define $s^h_{i,j,t}$ to be firm j's cost share of factor h to nominal sales in year t, and $\eta_{i,j,t}$ be the elasticity of scale in production ($\eta_{i,j,t} = \sum_{h \in \{K,L,M\}} \beta^h_{i,j,t}$). Substituting (23) and (24) into (22) yields:

$$y_{i,j,t} = a_{i,j,t} + \mu_{i,j,t}x^V_{i,j,t} + \eta_{i,j,t}x^K_{i,j,t}, \tag{25}$$

where $x^V_{i,j,t} = \sum_{h \neq K} \tilde{s}^h_{i,j,t}(x^h_{i,j,t} - x^K_{i,j,t})$ and $\tilde{s}^h_{i,j,t} = (s^h_{i,j,t} + s^h_{i,r,0})/2$.

[12]Following Kiyota (2010), we define the reference firms as sample mean values in the first year of our estimation period.

Manipulating (25), Kiyota (2010) proposes a feasible estimation model that enables simultaneous estimation of industry-level TFP growth and markup. Specifically, he assumes that TFP, markup, and the elasticity of scale are additively decomposable into industry specific factors and firm-level heterogeneous shocks, and then derives the following model.

$$\Delta y_{i,j,t} = \Delta a_{i,t} + \Delta\mu_{i,t}\overline{x}^{V}_{i,j,t} + \overline{\mu}_{i,t}\Delta x^{V}_{i,j,t} + \Delta\eta_{i,t}\overline{x}^{K}_{i,j,t} + \overline{\eta}_{i,t}\Delta x^{K}_{i,j,t} + u_{i,j,t}, \tag{26}$$

where $a_{i,t}$, $\mu_{i,t}$, and $\eta_{i,t}$ indicates industry specific TFP, markup, and the elasticity of scale, respectively, Δ indicates the first difference and an upper bar represents two year average. $\Delta a_{i,t}$, $\Delta\mu_{i,t}$, $\overline{\mu}_{i,t}$, $\Delta\eta_{i,t}$, and $\overline{\eta}_{i,t}$ are the parameters to be estimated, and $u_{i,j,t}$ indicates an error term of this estimation model. According to Kiyota (2010), we also assume that all RHS variables except year dummies are weakly exogenous with respect to $u_{i,j,t}$. We therefore estimate the model by Panel-GMM using the lagged variables as instrumental variables.[13] Estimating (26) by industry enables us to obtain industry-level markup ($\overline{\mu}_{i,t}$) and TFP growth ($\Delta a_{i,t}$).

5.2 Data Description

Following Kiyota (2010), who first apply Krette's (1999) method to the Japanese industries, we use the Basic Survey of Japanese Business Structure and Activities (BSJBSA) conducted by the Ministry of Economy, Trade and Industry of the Japanese Government.

The survey covers Japanese firms with more than 50 employees and 30 million yen in capital and contains data on firm-level tangible assets, the number of employees, sales, intermediate inputs, and industrial classifications. More than 20,000 firms respond to the survey every year. Since the BSJSA is a follow up survey conducted every year since 1994, we can use the series of BSJSA as a panel data for our estimation.

However, the information on industrial deflators of outputs and intermediate goods, labor costs, working hours per employee and nominal capital costs, which are necessary for the calculation of real values and cost shares, are not available from the survey. To address this problem, we use the Japanese Industrial Productivity (JIP) database, which provides industry-level information on them. And to supplement the lacking information to our data, we utilize the concordance of industrial classifications provided by Research Institute of Economy, Trade and Industry (RIETI). Following Nishimura, Nakajima, and Kiyota (2005), we classified the sample into 15 industries based on the Japanese SNA (System of National Account) middle classification. The specific industry definitions are shown in Table 5.[14]

[Table 5]

For the estimation, we use balanced panel data from 1994 to 2004. That is, we use the firms that survived and consistently responded to the survey during the period. Because the BSJBSA is conducted by the government and thus compulsory for firms, we believe that the problem of attrition is not serious in our data.

[13] When implementing Panel-GMM, we follow the procedures explained in Wooldridge (2010, ch.11).

[14] Differently from Nishimura, Nakajima, and Kiyota (2005), we discarded the samples in agriculture, forestry and fishing industry; mining industry; electricity, gas and water supply industry; financial industry; real-estate industry and transportation and telecommunication industry, because we cannot obtain plentiful observations for estimation.

5.3 Data Construction

Following Nishimura, Nakajima, and Kiyota (2005) and Kiyota (2010), we define variables used for our estimation as follows. Specifically, we construct firm-level variables on real output, intermediate inputs, labor inputs, capital stocks and user costs of capital.

First, output is defined as sales divided by industrial gross output price index obtainable from the JIP database. The industrial gross output index is defined as the ratio between nominal industrial gross output and real industrial gross output (the base year is 2000). Similarly, intermediate inputs are calculated as firm-level nominal intermediate inputs divided by the industrial input price index. The former are defined as the sum of sales costs and administrative costs minus wage payments and depreciation costs. Labor inputs are defined as firm-level number of employees multiplied by the industry average working hours per employees.

The BSJBSA data provide the information on the total amount of fixed intangible assets, but do not include their detailed items (such as land, building, machinery, equipment, and vehicles). Fortunately, information on the ratio of land to total intangible assets is available from the 1995 and 1996 surveys. Using this information, we calculate industry average land ratio in 1995 and 1996 to remove land from fixed tangible assets, assuming the ratio does not change during the estimation period.[15]

Real capital stocks are estimated following the method proposed by Nishimura, Nakajima, and Kiyota (2005). We first deflate book values of capital stock in the initial year (i.e. 1994) by industrial investment goods price index to obtain initial value of capital stock, and then calculate real capital stocks according to:

$$X^K_{i,j,t+1} = \begin{cases} X^K_{i,j,t} + \frac{(X_{i,j,t+1} - X_{i,j,t})}{P^I_t} & \text{if } (X_{i,j,t+1} - X_{i,j,t}) \geq 0, \\ X^K_{i,j,t} + (X_{i,j,t+1} - X_{i,j,t}) & \text{if } (X_{i,j,t+1} - X_{i,j,t}) < 0, \end{cases}$$

where $X^K_{i,j,t}$, $X_{i,j,t}$ and P^I_t stand for real capital stocks, book values of capital stocks and industrial investment goods price index, respectively. As shown in the equation, we assume that firms make capital expenditures when positive increments in book values of capital stock are observed, and deflate them by investment goods price index to obtain increments in real capital. When book values are decreasing, we assume that only depreciation occurs and remove the amount from the real capital of previous year.

As for nominal user costs, we define them as firm-level real capital stocks multiplied by industrial nominal capital user costs per real capital. The latter are similarly obtained from the JIP data base. Before estimation, we remove observations that are larger or smaller than 99 or 1 percentile points of each variable as outliers. After this manipulation there are 11,981 firms in each year. The number of firms are not less than 100 in each industry, which is enough to implement GMM estimations.

[15]Concretely, we calculate two year averaged land ratio (θ) for each industry and then multiply fixed tangible assets by $(1 - \theta)$ to obtain the book value of capital stocks.

5.4 Estimation Results

Because we have a lot of parameters and consequently reporting all of estimation results is impossible, we only report the sample period (i.e. 1996-2004) averages of industry-level markup and TFP growth. They are calculated as the sample period arithmetic means of $\bar{\mu}_{i,t}$ and $\Delta a_{i,t}$, respectively.[16] Detailed estimation results are shown in Table 6.

[Table 6]

The estimated markups of 15 industries range from 0.7174 to 1.3954, and the estimated values are not so different from those by Klette (1999), where the estimated markups range from 0.649 to 1.088, and by Kiyota (2010), where they range from 0.825 to 1.104. Our estimation results are considered to be plausible. The correlation between the estimated markups and TFP growth rates is shown in Figure 4 (a). We find that TFP growth is negatively associated with the markup as expected from our theoretical model.

[Figure 4]

In order to examine the second result of our theoretical results, namely, the shift of employment from low markup industries to high markup industries, we examine the correlation between industry-level growth in labor inputs and estimated markup. The industry-level labor inputs are again obtained from the JIP database, and they are defined as the total number of employees in each industry within a year. We calculate sample period (i.e. 1996-2004) averages of the growth for each industry. As shown in Figure 4 (b), we find positive correlation between markup and growth in labor inputs.[17]

These empirical results demonstrate that average productivity growth is higher in the sectors with relatively low markup than in the sectors with relatively high markup. In addition, combining our estimation results with semi-macro industrial data, we find that the shares of employments are gradually shifting from the former to the latter sectors. These empirical results support the validity of the prediction of our theoretical model.

6 Welfare Analysis

To complete our analysis, we derive the socially optimal allocation and then discuss the optimal policy. To present our results in a simple and clear-cut manner, we make some simplifications. First, we assume that the unit of managers required in investment activities are $a(z) = fe^{\xi \cdot z}$, where $f > 0$ and $\xi > 0$ are constant parameters, as in Young (1998). Second, this section assumes $\sigma_1 = \sigma_2 \equiv \sigma > 0$ because the difference between σ_1 and σ_2 plays no role in generating structural change, as we observed in Sections 4. Finally, we focus on $\varepsilon < 1$ because it provides the most plausible case empirically.

[16] Before measuring correlation, we remove estimation results from industries with markup significantly lower than 1 at the significance level of 5 percent. This is done by the one-tailed z-tests, and standard errors for each estimated markup are calculated by the delta method. As a result, we discard results from manufacture of ceramic, stone, and clay; manufacture of metal; and manufacture of precision machined components. However, we found similar results in the case which this three industries are included.

[17] We also observed a positive correlation between the growth in industrial man-hours and markup.

6.1 Socail Optimum

We begin with the socially optimal allocation. Because the initial productivity of each brand in the same sector is the same and each brand in the same sector is produced by the same production technology, we have $C_i(t) = n_i(t)^{\sigma+1}x_i(t)$ from (2). Then, the social planner maximizes:

$$U(t) = \sum_{s=t}^{\infty} \beta^{s-t} \ln \left\{ \gamma [n_1(t)^{\sigma+1} x_1(t)]^{\frac{\varepsilon-1}{\varepsilon}} + (1-\gamma)[n_2(t)^{\sigma+1} x_2(t)]^{\frac{\varepsilon-1}{\varepsilon}} \right\}^{\frac{\varepsilon}{\varepsilon-1}}. \tag{27}$$

subject to the two resource constraints that are given by (14), where $L_{M,i}(t)$ and $L_{P,i}(t)$ are given by (12) and (13), respectively. It should be noted that in the planner's problem, variables associated with Sectors 1 and 2 appear in a symmetrical manner, except for γ and $1-\gamma$. We can prove the next proposition.

Proposition 4
Suppose $\sigma_1 = \sigma_2 \equiv \sigma > 0$. The socially optimal growth rate of $b_i(t)$ is given by:

$$g_1 = g_2 = \frac{1}{(1-\beta)\sigma\xi} \equiv g^{opt}. \tag{28}$$

The socially optimal levels of $n_1(t)$ and $n_2(t)$ remain constant over time at $n_1{}^{opt}$ and $n_2{}^{opt}$, respectively. $n_1{}^{opt}$ and $n_2{}^{opt}$ satisfies the following two equations:

$$\frac{n_2{}^{opt}}{n_1{}^{opt}} = \left(\frac{1-\gamma}{\gamma}\right)^{\frac{\varepsilon}{1+\sigma(1-\varepsilon)}} \left(\frac{b_{1,0}}{b_{2,0}}\right)^{\frac{1-\varepsilon}{1+\sigma(1-\varepsilon)}} \quad \textit{and} \quad L_M = (n_1{}^{opt} + n_2{}^{opt})a(g^{opt}). \tag{29}$$

The socially optimal production level of firms in Sector i, which we denote as $x_i{}^{opt}(t)$, grows at the rate of g^{opt}, and satisfies:

$$\frac{x_2{}^{opt}(t)}{x_1{}^{opt}(t)} = \frac{b_{2,0}}{b_{2,0}} \quad \textit{and} \quad L_P = \frac{n_1{}^{opt}x_1{}^{opt}(t)}{b_1(t)} + \frac{n_2{}^{opt}x_2{}^{opt}(t)}{b_2(t)}. \tag{30}$$

In the socially optimal allocation, the numbers of managers and production labor allocated to Sector i are both constant over time at $L_{M,i}{}^{opt} \equiv n_i{}^{opt}a(g_i{}^{opt})$ and $L_{P,i}{}^{opt} \equiv n_i{}^{opt}x_i{}^{opt}(t)/b_i(t)$.
(Proof) See Appendix B.

In the social optimal allocation, the structural change does not occurs. The shares of production labor and managers allocated to one sector remain constant over time. When $\alpha_1 > \alpha_2$ and $\varepsilon \neq 1$ hold, the market equilibrium cannot achieve the socially optimal allocation without any interventions of the government.

The following points deserve to be mentioned. The elasticities of substitution between any two brands of the same good, α_1 and α_2, have no effects on the socially optimal allocation. Only the taste for variety, σ, influences the optimal allocation, as shown in (28). Then, if $\sigma_1 \neq \sigma_2$ holds, the growth rate of $b_2(t)$ can be different from that of $b_1(t)$ and hence the structural change occurs even in the socially optimal allocation. However, even if $\sigma_1 \neq \sigma_2$ holds, the socially optimal allocation is not influenced by α_1 and α_2. Therefore, the market equilibrium cannot achieve the socially optimal allocation without any interventions of the government. To obtain a clear-cut result, we focus on the case of $\sigma_1 = \sigma_2 \equiv \sigma$, here.

6.2 Optimal Taxes

This subsection addresses the question of whether the optimal allocation is realized through the government interventions in the market economy. We consider consumption taxes, production subsidies, investment subsidies and entry fee imposed by the government.

The introduction of consumption taxes, and production subsidies modify (3) and the operating profits of firm i in Sector i as follows:

$$E_i(t) = \int_0^{n_i(t)} (1+\tau_i^c) p_{i,j}(t) x_{i,j}(t) dj, \quad \text{and} \quad \pi_{i,j}(t) = \left[p_{i,j}(t) - \frac{1-\tau_i^P}{b_{i,j}(t)} \right] x_{i,j}(t),$$

where τ_i^c is the consumption tax rate for good i and τ_i^P represents the production subsidies for firms in Sector i. Let us denote the investment subsidy rate as τ_i^I. We assume that to produce in period t, firms must pay the administration (entry) fee to the government. The administration requires τ_i^E units of managers. Then, (8) is modified as:

$$\Pi_{i,j}(t-1) = \frac{\pi_{i,j}(t)}{1+r(t-1)} - (1-\tau_i^I) a \left(\frac{b_{i,j}(t)}{\bar{b}_{i,j}(t-1)} \right) w_M(t-1) - T_i^E(t-1).$$

where $T_i^E(t-1) = \tau_i^E w_M(t-1)$. We can show the following proposition.

Proposition 5
If the government sets $1-\tau_i^I = \alpha_i(1-\beta)\sigma/(1-\alpha_i)$, $\tau_i^E = \tau_i^I a(g^{opt})$, $(1-\tau_1^P)/(1-\tau_2^P) = \{\alpha_1(1-\alpha_2)\}/\{\alpha_2(1-\alpha_1)\}$ *and* $(1+\tau_1^c)/(1+\tau_2^c) = (1-\alpha_1)/(1-\alpha_2)$, *the socially optimal allocation can be achieved in the market economy.*

(Proof) See Appendix C.

To discuss the characteristics of the optimal policy, we focus on the case of $\alpha_1 > \alpha_2$ and $\varepsilon < 1$ where the production shifts from the progressive Sector 1 to the stagnant Sector 2. Depending on parameter values, τ_i^I and τ_i^E, become either positive or negative. Because we are interested in the relationship between τ_1^Z and τ_2^Z where $Z = I$ or E, we pay less attention to signs of τ_i^I and τ_i^E.[18] The inequality, $\alpha_1 > \alpha_2$, implies $\tau_1^I < \tau_2^I$. The government should subsidize productivity improvements of the stagnant sector more than those of the progressive sector. Because of $\tau_1^I < \tau_2^I$, we have $\tau_1^E < \tau_2^E$, which suggests that the government should impose a higher entry fee for firms entering into the technologically stagnant sector. We also have $\tau_1^P < \tau_2^P$ and $\tau_1^c < \tau_2^c$. The production of firms with higher markup ratio should be subsidized more. The government should impose a higher consumption taxes on the consumption of goods whose nominal expenditure share increases over time.

[18] If σ is small (large) enough to satisfy $\sigma < (>)(1-\alpha_i/\{\alpha_i(1-\beta)\}$, both τ_i^I and τ_i^E are positive (negative). When the taste for variety is weak (strong), the government should impose taxes on (subsidize) productivity improvements and entry of firms.

7 Conclusion

We construct an endogenous growth model that explains the observed pattern of the structural change. Unlike the existing studies, we assume neither non-homothetic preferences nor exogenous differential in productivity growth among different sectors. The driving force of structural change in our setting is the difference in the elasticities of substitution among the two sectors, which generates the unbalanced productivity growth endogenously. When the two composite goods are poor substitute, shares of employment and nominal consumption expenditure shift from the progressive to the stagnant sectors gradually.The relative price of the composite good of the stagnant sector increases over time.

In contrast to the previous studies, we study the socially optimal allocation and characterize the optimal tax policies. Our results suggest the following four points: (i) The government should subsidize productivity improvements of the stagnant sector more than those of the progressive sector. (ii) The government should impose a higher entry fee for firms entering into the growing sector. (iii) The production of firms faced with price less-elastic demand should be subsidized more. (iv) The government should impose a higher consumption taxes on consumption of goods whose nominal expenditure share increases gradually.

Appendix

A The Derication of (10)

Using (5), (9) and the definition of $\pi_{i,j}(t)$, we derive:

$$x_{i,j}(t) = \frac{\alpha_i E_i(t) b_{i,j}(t)^{\frac{1}{1-\alpha}}}{\int_0^{n_i(t)} b_{i,j'}(t)^{\frac{\alpha_i}{1-\alpha_i}} dj'}, \quad \text{and} \quad \pi_{i,j}(t) = \frac{(1-\alpha_i) E_i(t) b_{i,j}(t)^{\frac{\alpha_i}{1-\alpha_i}}}{\int_0^{n(t)} b_{i,j'}(t)^{\frac{\alpha_i}{1-\alpha_i}} dj'}. \tag{A.1}$$

In the second step of the firm's problem, firm j in Sector i chooses $b_{i,j}(t)$ so as to maximize $\Pi_{i,j}(t-1)$ subject to the second equation of (A.1). The first order condition is given by:

$$\frac{\partial \pi_{i,j}(t)/\partial b_{i,j}(t)}{1+r(t-1)} = \frac{1}{\bar{b}_{i,j}(t-1)} a' \left(\frac{b_{i,j}(t)}{\bar{b}_{i,j}(t-1)} \right) w_M(t-1). \tag{A.2}$$

The free entry implies that $\Pi_{i,j}(t-1)$ is equal to zero in equilibrium.

$$\frac{\pi_{i,j}(t)}{1+r(t-1)} = a \left(\frac{b_{i,j}(t)}{\bar{b}_{i,j}(t-1)} \right) w_M(t-1). \tag{A.3}$$

Dividing the both sides of (A.2) by (A.3) and after some manipulations using the first equation of (A.1), we obtain (10).

B The Socially Optimal Allocation

Maximizing (27) subject to (12), (13) and (14) yields the following first order considtions:

$$u(t)^{\frac{1-\varepsilon}{\varepsilon}}\hat{\gamma}_i\left(n_i(t)^{\sigma+1}x_i(t)\right)^{\frac{\varepsilon}{1-\varepsilon}}\frac{1}{x_i(t)} = \lambda(t)\frac{n_i(t)}{b_i(t)}, \tag{B.1a}$$

$$u(t)^{\frac{1-\varepsilon}{\varepsilon}}(\sigma+1)\hat{\gamma}_i\left(n_i(t)^{\sigma+1}x_i(t)\right)^{\frac{\varepsilon}{1-\varepsilon}}\frac{1}{n_i(t)} = \lambda(t)\frac{x_i(t)}{b_i(t)} + \mu(t)a(g_i(t)), \tag{B.1b}$$

$$\lambda(t)\frac{n_i(t)x_i(t)}{b_i(t)^2} - \mu(t)\frac{a'(g_i(t))n_i(t)}{b_i(t-1)} + \beta\mu(t+1)\frac{b_i(t+1)a'(g_i(t+1))n_i(t+1)}{b_i(t)^2} = 0, \tag{B.1c}$$

where $\hat{\gamma}_1 \equiv \gamma$, $\hat{\gamma}_2 \equiv 1-\gamma$, $u(t)$ is defined by (1), $\lambda(t)$ and $\mu(t)$ are the Lagrangian multipliers associated with the first and second equations of (14), respectively. The first equation is the first order condition for $x_i(t)$. The second and third ones are the first order conditions for $n_i(t)$ and $b_i(t)$.

Let us define $g_i(t) \equiv b_i(t)/b_i(t-1)$. From (1), (13), the first equation of (14) and (B.1a), we obtain $\lambda(t) = 1/L_P$. Similarly, from (1), (12), the second equation of (14) and (B.1b), we obtain $\mu(t) = \sigma/L_M$. Using (B.1a), $\lambda(t) = 1/L_P$ and $\mu(t) = \sigma/L_M$, we rearrange (B.1b) and then obtain:

$$\frac{x_i(t)}{L_P b_i(t)} = \frac{a(g_i(t))}{L_M}. \tag{B.2}$$

Substituting $a(z) = fe^{z\cdot\xi}$, (B.2), $\lambda(t) = 1/L_P$ and $\mu(t) = \sigma/L_M$ into (B.1c) and after some manipulations, we obtain:

$$g_i(t) = \frac{1}{\sigma\xi} + \beta\frac{n_i(t+1)a(g_i(t+1))}{n_i(t)a(g_i(t))}g_i(t+1). \tag{B.3}$$

From (B.1a), we yield:

$$\left(\frac{\gamma}{1-\gamma}\right)^{\varepsilon}\left(\frac{n_2(t)}{n_1(t)}\right)^{1+\sigma(1-\varepsilon)} = \left(\frac{b_2(t)}{b_1(t)}\right)^{\varepsilon}\frac{x_1(t)}{x_2(t)}, \tag{B.4}$$

We eliminate $x_1(t)$ and $x_2(t)$ from (B.4) using (B.2) and the solve for $n_2(t)/n_1(t)$:

$$\frac{n_2(t)}{n_1(t)} = \left[\left(\frac{1-\gamma}{\gamma}\right)^{\varepsilon}\frac{a(g_1(t))}{a(g_2(t))}\right]^{\frac{1}{1+\sigma(1-\varepsilon)}}\left(\frac{g_1(t)\cdots g_1(1)b_{1,0}}{g_2(t)\cdots g_2(1)b_{2,0}}\right)^{\eta\cdot t}, \tag{B.5}$$

where $\eta = \frac{1-\varepsilon}{1+\sigma_2(1-\varepsilon)}$. In deriving the above equation, we use $b_i(t) = g_i(t)b_i(t-1)$. From (13), the first equation of (14) and (B.2), or from (12), the second equation of (14) and $g_i(t) \equiv b_i(t)/b_i(t-1)$, we obtain:

$$L_M = a(g_1(t))n_1(t) + a(g_2(t))n_2(t). \tag{B.6}$$

Note that (B.3) holds for both $i = 1$ and $i = 2$. Given $b_{1,0}$ and $b_{2,0}$, equations, (B.3), (B.5) and (B.6) determine the sequence of $\{g_1(t),\ g_2(t),\ n_1(t),\ n_2(t)\}$. Because in (B.3), (B.5) and

(B.6), variables associated with Sectors 1 and 2 appear in a symmetrical manner, except for γ and $1-\gamma$, we conjecture that there exists an equilibrium where $n_1(t)$ and $n_2(t)$ remain constant over time. Then, we verify the existence of such equilibrium. We know from (B.5) that if $n_1(t)$ and $n_2(t)$ remain constant over time, we have $g_1(t) = g_2(t) \equiv g(t)$ over time. We omit the index i from (B.3). Because $n_1(t)$ and $n_2(t)$ remain constant over time, (B.3) becomes a difference equation for $g(t)$; $\beta a(g(t+1))g(t+1) = a(g(t))g(t) - a(g(t))/(\sigma\xi)$. Then, we have:

$$a(g(t+1))g(t+1) - a(g(t))g(t) = \frac{(1-\beta)a(g(t))}{\beta}\left(g(t) - \frac{1}{(1-\beta)\sigma\xi}\right). \tag{B.7}$$

The above equation shows that $g(t)$ remains constant at $g^{opt} \equiv 1/\{(1-\beta)\sigma\}$ over time because (B.6) must be satisfied. Then, (B.5) and (B.6) corresponds to the two equations of (29). Apparently, both $n_1(t)$ and $n_2(t)$ become constant over time, as we conjectured. Because $g_i(t)$ is contant at g^{opt}, (B.2) shows that $x_i(t)$ grows the same rate as $b_i(t)$ and $x_i{}^{opt}(t)$ satisfies (30). $L_{P,i}{}^{opt}$ is equal to $x_i{}^{opt}(t)n_i{}^{opt}(t)/b_i(t)$ that is constant over time. The existence of the equilibrium where $n_i(t)$ remains constant over time is verified.

C The Optimal Tax

The presence of τ_i^c modifies (5) as:

$$x_{i,j}(t) = \frac{E_i(t)p_{i,j}(t)^{-\frac{1}{1-\alpha_i}}}{(1+\tau_i^c)\int_0^{n_i(t)} p_{i,j'}(t)^{-\frac{\alpha_i}{1-\alpha_i}}dj'}. \tag{C.1}$$

The relative nominal expenditure and the Euler equation are still given by the second equation of (6) and (7), respectively. The price index of composite i is given by $P_i(t) \equiv (1+\tau_i^c)n_i(t)^{\frac{1-\alpha_i}{\alpha_i}-\sigma}\left[\int_0^{n_i(t)} p_{i,j}(t)^{-\frac{\alpha_i}{1-\alpha_i}}dj\right]^{-\frac{1-\alpha_i}{\alpha_i}}$. The maximization of the operating profits results in $p_{i,j}(t) = (1-\tau_i^P)/(\alpha_i b_{i,j}(t))$.

The maximization of $\Pi_{i,j}(t-1)$ and the free entry condition, $\Pi_{i,j}(t-1) = 0$, yield:

$$\frac{\alpha_i}{1-\alpha_i} = \frac{(1-\tau_i^I)g_i(t)a'(g_i(t))}{(1-\tau_i^I)g_i(t)a(g_i(t)) + \tau_i^E}, \tag{C.2}$$

where $a(z) = fe^{\xi \cdot z}$. We know that if the government set $1-\tau_i^I = \alpha_i(1-\beta)\sigma/(1-\alpha_i)$ and $\tau_i^E = \tau_i^I a(g^{opt})$, the solution of (C.2) is given by $g_1 = g_2 = g^{opt}$. The socially optimal growth rate of $b_i(t)$ is obtained. In equilibrium, the free entry condition implies:

$$\frac{\pi_{i,j}(t)}{1+r(t-1)} = (1-\tau_i^I)a\left(\frac{b_{i,j}(t)}{\bar{b}_{i,j}(t-1)}\right)w_M(t-1) + T_i^E(t-1) = a(g^{opt})w_M(t-1). \tag{C.3}$$

Because of the symmetry among firms in the same sector, we have:

$$p_{i,j}(t) = \frac{1-\tau_i^P}{\alpha_i b_i(t)}, \quad x_{i,j}(t) = \frac{E_i(t)}{(1+\tau_i^c)n_i(t)p_i(t)}, \quad \pi_{i,j}(t) = \frac{(1-\alpha_i)E_i(t)}{(1+\tau_i^c)n_i(t)}. \tag{C.4}$$

From (C.3), (C.4), $g_1 = g_2 = g^{opt}$ and $b_i(t) = g^{opt^t} b_{i,0}$, we obtain:

$$\frac{x_2(t)}{x_1(t)} = \frac{\alpha_2(1-\alpha_1)b_{2,0}}{\alpha_1(1-\alpha_2)b_{1,0}} \frac{1-\tau_1^P}{1-\tau_2^P}. \tag{C.5}$$

When the government sets $(1-\tau_1^P)/(1-\tau_2^P) = \{\alpha_1(1-\alpha_2)\}/\{\alpha_2(1-\alpha_1)\}$, (C.5) takes the same form as the first equation of (30). Because (13) and the first equation of (14) still hold, if the optimal levels of $n_1(t)$ and $n_2(t)$ is realized, the optimal production level of firms and the optimal number of production labor allocated to Sector i are also realized.

We then proceed the derivations of $n_1(t)$ and $n_2(t)$. Following the same procedure as the derivation of (20) in Section 4, we use the second equation of (6), (C.3), the first and the third equations of (C.4), $P_i = (1+\tau_i^c)n_i(t)^{\sigma} p_i(t)$, $(1-\tau_1^P)/(1-\tau_2^P) = \{\alpha_1(1-\alpha_2)\}/\{\alpha_2(1-\alpha_1)\}$ and $g_1 = g_2 = g^{opt}$ to obtain:

$$n_2(t) = \Gamma n_1(t), \tag{C.6}$$

where $\Gamma = \left[\left(\frac{1-\gamma}{\gamma}\right)^{\varepsilon}\left(\frac{1+\tau_1^c}{1+\tau_2^c}\frac{1-\alpha_2}{1-\alpha_1}\right)^{\varepsilon}\right]^{\frac{1}{1+\sigma_2(1-\varepsilon)}}\left(\frac{b_{1,0}}{b_{2,0}}\right)^{\frac{1-\varepsilon}{1+\sigma(1-\varepsilon)}} > 0$. When the government sets $(1+\tau_1^c)/(1+\tau_2^c) = (1-\alpha_1)/(1-\alpha_2)$, (C.6) takes the same form as the first equation of (29). Because (12) and the first equation of (14) still hold, the optimal $n_1(t)$ and $n_2(t)$ are realized. We obtain Proposition 8.

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	US		Japan		Germany	
	1980	2005	1980	2005	1980	2005
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0
ICT PRODUCTION	6.1	4.7	5.1	5.8	6.8	5.3
GOODS	31.5	21.8	39.1	27.1	39.1	26.7
Manufacturing	19.2	11.8	23.9	17.4	25.4	19.3
Other goods	12.4	10.0	15.2	9.7	13.8	7.3
SERVICES	62.4	73.5	55.8	67.1	54.1	68.0
Market services	32.9	40.7	34.7	39.9	29.8	38.4
Distribution	16.9	14.5	19.0	18.1	14.3	14.1
Finance and Business	11.2	19.7	8.4	14.3	10.4	17.6
Personal	4.8	6.4	7.3	7.5	5.2	6.8
Non-market services	29.5	32.8	21.1	27.2	24.3	29.6

	France		UK	
	1980	2005	1980	2005
TOTAL	100.0	100.0	100.0	100.0
ICT PRODUCTION	4.6	3.5	5.6	4.3
GOODS	35.0	21.6	42.7	22.9
Manufacturing	19.3	11.8	23.8	11.8
Other goods	15.7	9.7	18.9	11.2
SERVICES	60.4	74.9	51.8	72.8
Market services	34.2	39.8	31.0	46.2
Distribution	14.8	14.8	15.2	16.3
Finance and Business	14.5	18.5	10.3	21.5
Personal	4.8	6.5	5.5	8.3
Non-market services	26.3	35.1	20.8	26.6

Table 1: Gross value-added by sector as a percentage of GDP
Source: Caluclated based on EU KLEMS database.

	US		Japan		Germany	
	1980	2005	1980	2005	1980	2005
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0
ICT PRODUCTION	5.1	3.2	4.0	3.8	5.5	3.7
GOODS	29.4	20.3	42.9	31.0	43.0	27.2
Manufacturing	18.8	10.4	20.3	15.7	25.5	17.1
Other goods	10.6	9.9	22.6	15.3	17.4	10.1
SERVICES	65.4	76.5	53.1	65.2	51.5	69.2
Market services	40.3	47.9	42.4	49.1	32.6	45.4
Distribution	20.4	18.8	24.2	21.6	19.1	19.7
Finance and Business	10.5	17.8	6.4	12.6	7.0	15.2
Personal	9.4	11.3	11.8	14.9	6.5	10.6
Non-market services	25.2	28.6	10.8	16.0	18.9	23.8

	France		UK	
	1980	2005	1980	2005
TOTAL	100.0	100.0	100.0	100.0
ICT PRODUCTION	3.7	3.0	5.3	3.3
GOODS	43.5	25.9	39.0	21.7
Manufacturing	19.9	12.2	24.2	11.2
Other goods	23.7	13.8	14.9	10.5
SERVICES	52.7	71.1	55.6	75.0
Market services	32.8	45.1	37.9	52.4
Distribution	17.3	18.3	21.2	20.8
Finance and Business	9.5	16.9	9.9	20.2
Personal	6.0	9.9	6.8	11.4
Non-market services	20.0	25.9	17.7	22.6

Table 2: Hours worked by sector as a percentage of total hours worked
Source: Caluclated based on EU KLEMS database.

	US	Japan	Germany	France	UK
TOTAL	0.0	0.0	0.0	0.0	0.0
ICT PRODUCTION	-3.5	-3.0	-1.6	-3.1	-2.6
GOODS	-0.2	-0.1	-0.1	-0.5	-0.7
Manufacturing	-0.4	-0.3	0.0	-0.7	-0.7
Other goods	0.2	0.3	-0.3	-0.1	-0.5
SERVICES	0.4	0.7	0.4	0.6	0.8
Market services	0.0	0.4	0.3	0.4	0.4
Distribution	-1.0	0.2	-0.3	-0.1	-0.2
Finance and Business	0.7	-0.1	0.7	0.6	0.7
Personal	0.8	1.4	1.2	1.2	1.1
Non-market services	1.5	1.5	0.2	1.1	1.7

Table 3: Output prices (average annual compound growth rates), 1980-2005
Source: Caluclated based on EU KLEMS database.

	US	Japan	Germany	France	UK
TOTAL	1.7	2.9	2.1	2.2	2.2
ICT PRODUCTION	7.6	9.2	4.9	5.5	7.2
GOODS	1.8	2.9	2.4	3.4	3.1
Manufacturing	2.5	3.2	2.5	3.3	3.5
Other goods	0.8	2.1	2.2	3.5	2.6
SERVICES	1.5	2.1	1.5	1.2	1.7
Market services	2.0	2.5	1.3	1.2	2.1
Distribution	3.5	3.3	2.5	2.7	3.0
Finance and Business	0.9	2.9	0.4	0.2	1.8
Personal	1.2	0.4	-0.1	0.0	0.5
Non-market services	0.1	1.0	2.1	1.2	0.1

Table 4: Real value-added per hours worked (average annual compound growth rates), 1980-2005
Source: Caluclated based on EU KLEMS database.

		Industry classifications		
Industry	N of firms	SNA	JIP	BSJBSA
Manufacture of foods	744	3	8-14	90,121-123,129,131,132
Manufactue of textile, pulpe and paper	416	4,5	15, 18, 19	141,149,151
Manufacture of chemistry	567	6	23-29	170,181,182,191-193,201
Manufacture of petroreum and coal products	406	7	30,31	202,203
Manufacture of ceramic, stone, and clay	287	8	32-35	204,205,209,211
Manufacture of metal	442	9	36-39	219,220,231,239
Manufacture of metal products	618	10	40,41	240,251
Manufacture of machinery	937	11	42-45	252,259,261,262
Manufacture of electric appliances	1024	12	46-53	271,272,281,289,291-293,299
Manufacture of transportation equipment	650	13	54-56	301-303
Manufacture of precision machined components	229	14	57,58	304
Other manufacuturing	934	15	16,17,59	142,143,304
Construction	226	16	60,61	309,311
Wholesale trade	2963	18	67	330
Retail trade	1538	18	68	340

Table 5: Industry classification and the number of firms in each industry
Notes: Figures stand for industry classification codes of SNA, JIP and BSJBSA.

	Hansen's J test		Mark-up			TFP growth			N of employees
Industry	Test stats.	p-values	Estimates		Std.err.	Estimates		Std.err.	Growth rates
Manufacture of foods	43.452	0.1837	0.9090	***	0.1644	0.0024		0.0017	-0.84 %
Manufacture of textile, pulp and paper	25.596	0.9012	0.9351	***	0.0950	0.0135	***	0.0042	-6.75 %
Manufacture of chemistry	55.636	0.0194	0.7489		0.6826	0.0177	***	0.0060	-2.17 %
Manufacture of petroleum and coal products	44.019	0.1685	0.8837	**	0.3480	0.0054		0.0107	-3.34 %
Manufacture of ceramic, stone, and clay	50.979	0.0502	0.8155	***	0.0766	0.0361	***	0.0065	-4.20 %
Manufacture of metal	30.969	0.7066	0.7436	***	0.1375	0.0211	***	0.0048	-3.00 %
Manufacture of metal products	34.692	0.5307	0.9509	***	0.0511	0.0007		0.0033	-2.52 %
Manufacture of machinery	35.537	0.4904	0.9412	***	0.1381	0.0124	***	0.0035	-1.13 %
Manufacture of electric appliances	39.984	0.2976	0.9523	***	0.0780	0.0462	***	0.0043	-2.31 %
Manufacture of transportation equipment	37.352	0.4068	1.1119		0.8087	-0.0049		-0.0262	0.08 %
Manufacture of precision machined components	43.429	0.1843	0.8220	***	0.1030	0.0163	***	0.0034	-1.64 %
Other manufacturing	54.828	0.0230	0.7175		0.7887	0.0067		0.0095	-4.82 %
Construction	36.086	0.4646	0.9652	***	0.0810	-0.0173	***	-0.0039	-2.17 %
Wholesale trade	52.858	0.0346	1.0249	***	0.0727	-0.0148	***	-0.0020	-1.90 %
Retail trade	41.326	0.2492	1.3954	***	0.1370	-0.0183		-0.0176	-0.86 %

Table 6: Estimation results for period-average markup, TFP growth and labor input growth (1996-2004)

Notes: *,**,*** indicate the significance level of 10 percent, 5 percent and 1percent, respectively. Labor input growth is calculated based on the JIP database.

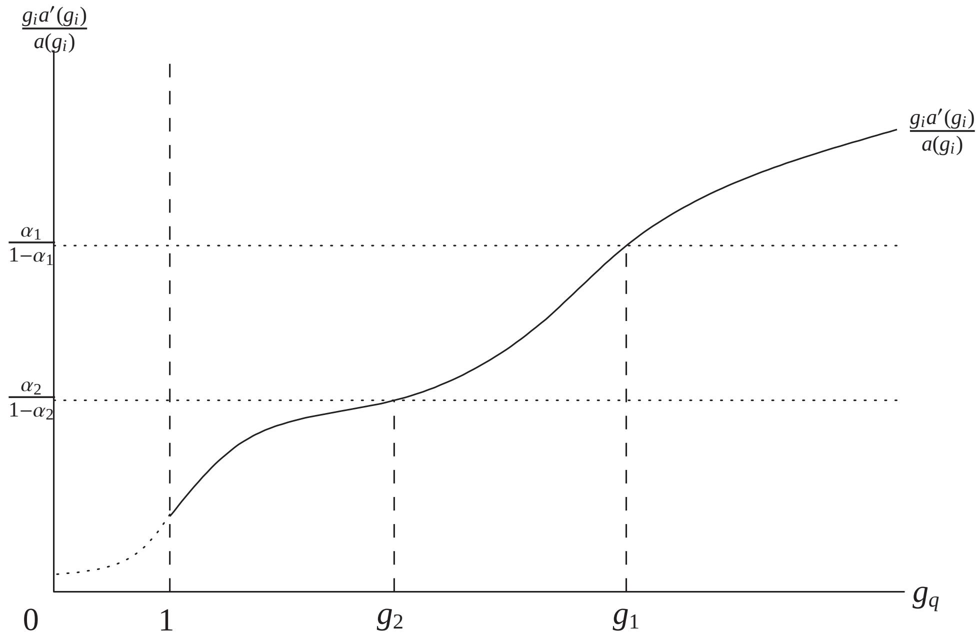


Figure 1. Productivity Growth Rate

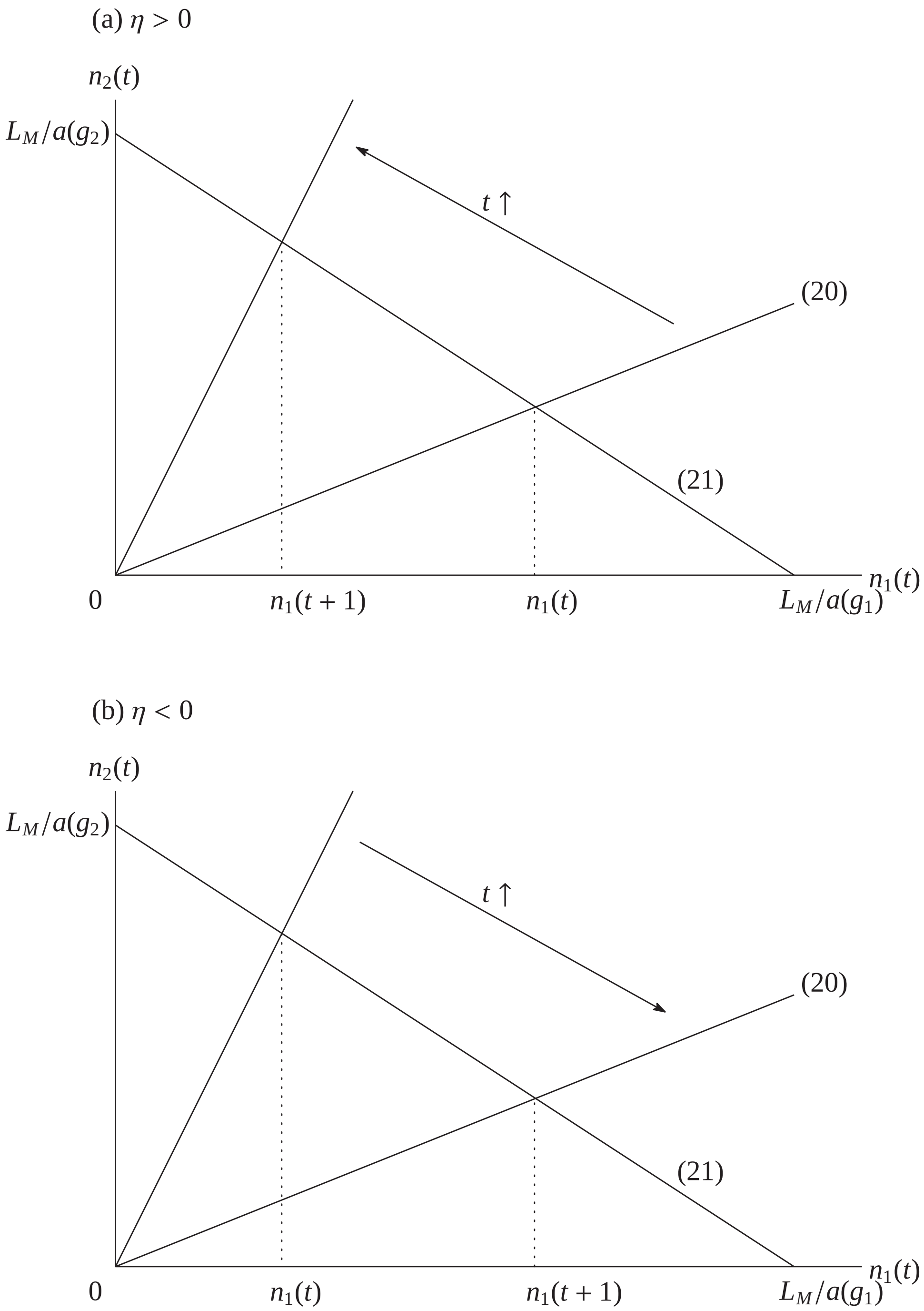
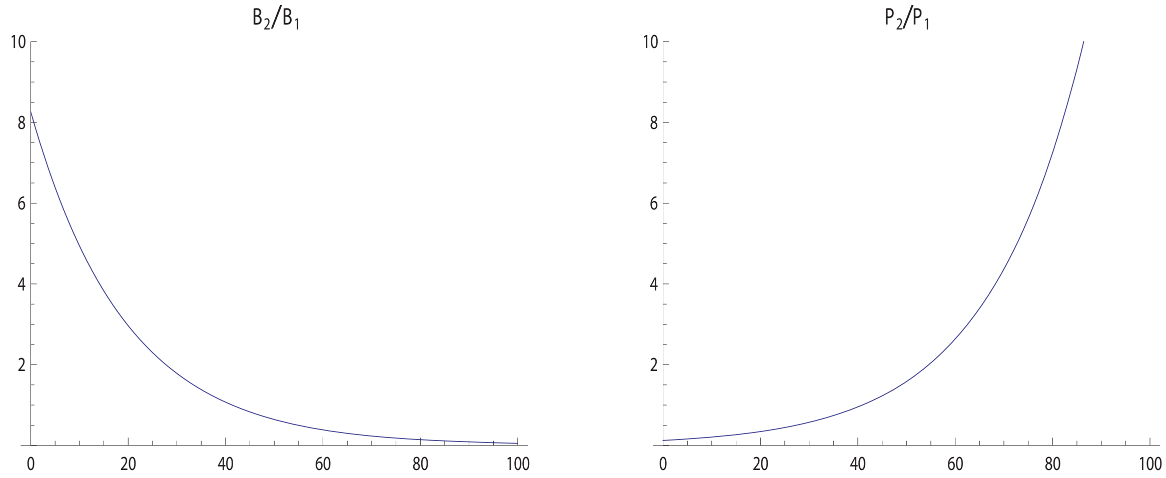


Figure 2. Equilibrium

(a) Relative Productivity and Price



(b) Expenditure and Employments

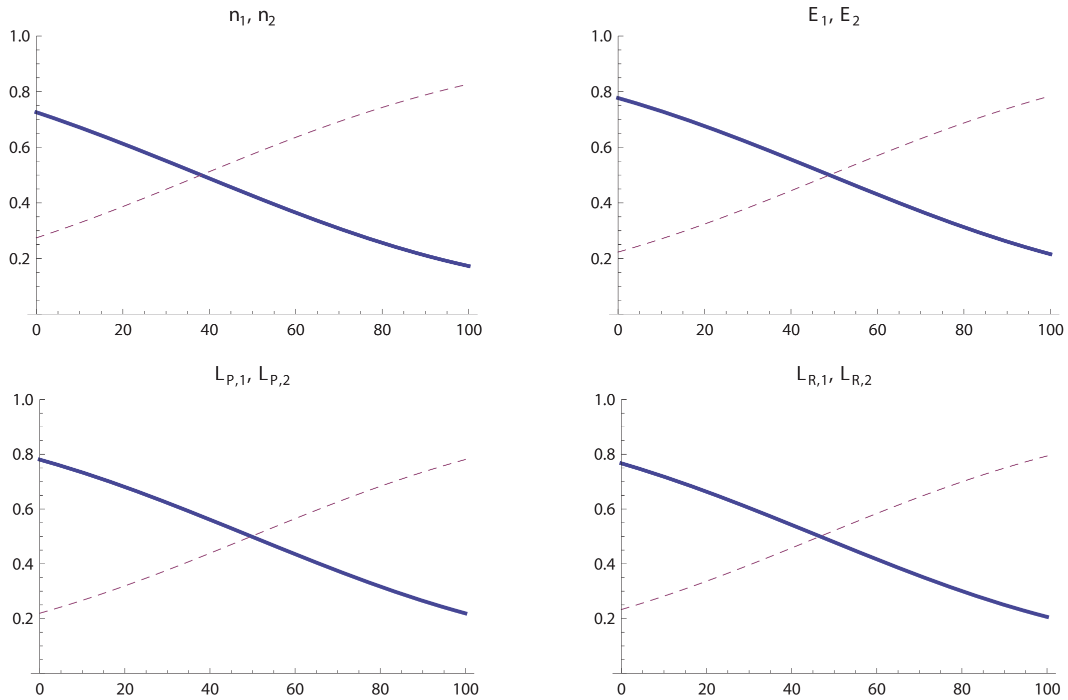
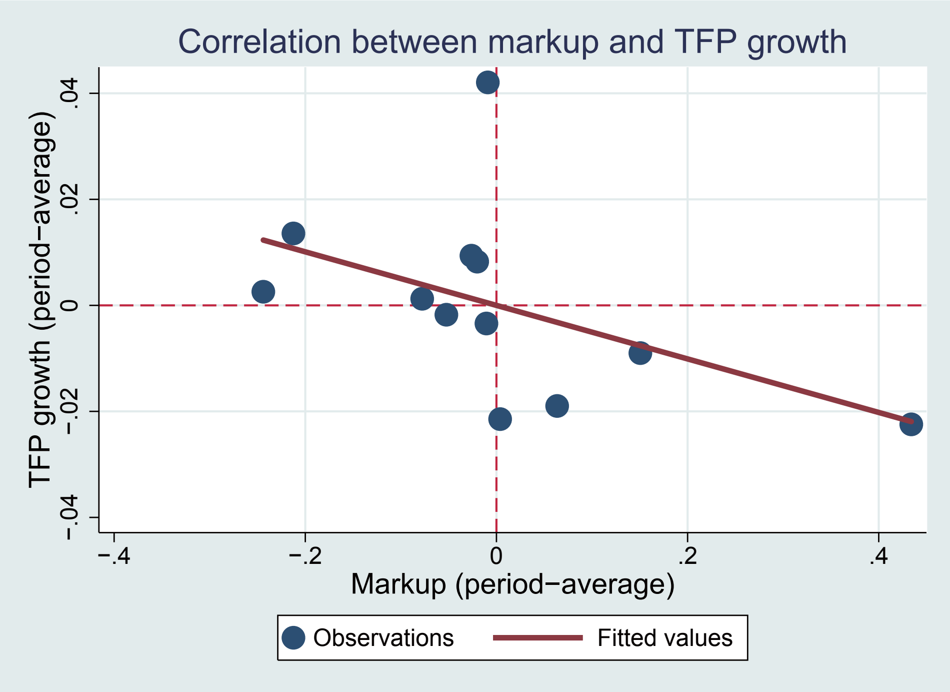


Figure 3. Structural Change: An Example

$L_P = 0.9$, $L_M = 0.1$, $\beta = 0.95$, $\varepsilon = 0.5$, $\gamma = 0.5$, $\sigma_1 = 1.1$, $\sigma_2 = 1$, $\alpha_1 = 0.745$, $\alpha_2 = 0.73$, $\xi = 2.66$, $f = 0.01$, $b_{10} = 0.1$, $b_{20} = 2$

(a)



(b)

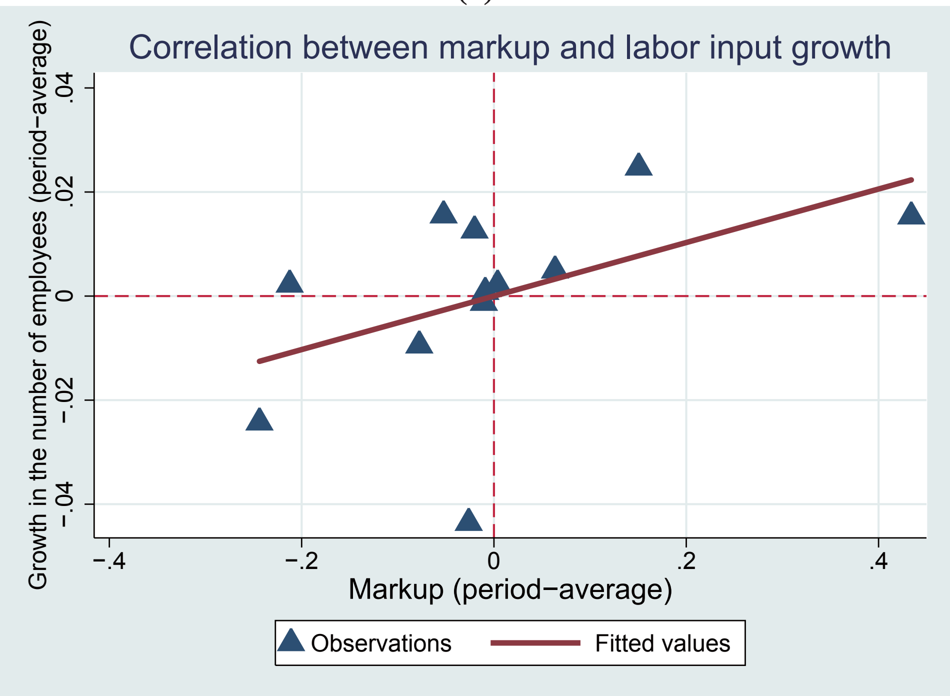


Figure 4. Correlations between markup, TFP growth and labor input growth

Notes: Markups, TFP growths, and labor input growths are measured as deviations from their respective means. Observations with markup significantly lower than 1 at the significance level of 5 percent are removed.