How career changes affect technological breakthrough - Reconsidering the prolonged slump of the Japanese economy -

Azuma, Yoshiaki

2010

The International Journal of Economic Policy Studies
Volume 4 2009 Article 2

HOW CAREER CHANGES AFFECT TECHNOLOGICAL BREAKTHROUGHS: RECONSIDERING THE PROLONGED SLUMP OF THE JAPANESE ECONOMY*

Yoshiaki AZUMA
Faculty of Economics, Doshisha University,

ABSTRACT

This paper develops a simple overlapping-generations model that relates career choices of highly educated workers to the rate of technological progress over time. The paper shows that, in the recent period of technological breakthroughs, if workers either acquire a sufficiently large number of firm-specific skills under the long-term employment system, or if they acquire an insufficient number of general skills even though they go through a change of careers, then an economy will be trapped in a low rate of technological progress. This result obtains because, under these conditions, the proportion of multi-career workers in an economy is lower, and thus the knowledge arising from breakthrough technological industries does not spill over into other types of industries. This result is consistent with the considerable differences observed in the rate of technological progress between the United States and Japan since 1990s.

Key words: Career Changes, Technological Breakthrough, the Japanese Slump, Information Technology, Shift to Services.

JEL Classification: J24, L16, L23, O31, O33, O57

* This research was conducted while I was a visiting research scholar at the Center for Japanese Studies, UC Berkeley. I would like to thank the referees and the editor for their helpful comments and suggestions. I would also like to acknowledge financial support from the "Academic Frontier" Project, 2004–2008, by Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) and from a special research grant for the promotion of the advancement of education and research in graduate schools provided in 2007 by MEXT and the Promotion and Mutual Aid Corporation for Private Schools of Japan.

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1. Introduction

This paper develops a simple overlapping-generations model that relates career choices of highly educated workers to the rate of technological progress over time. Although a recent high rate of economic growth in the United States is partly the result of excess liquidity, in the past few decades the United States has enjoyed the benefits of technological breakthroughs much more than Japan. The present paper sheds light on the factors which cause the quantitative differences in the rate of technological progress among developed countries.

As discussed widely in macroeconomics literature, the slump of the Japanese economy since the 1990s was originally caused by a massive slowdown of aggregate demand. Generally speaking, the policy to counteract the slump, at least in the short run, should be to enhance aggregate demand. However, because the Japanese slump still persists after seventeen years, it is meaningful to consider the structural problem which causes this slump. The present paper examines, within a macroeconomic framework, the differences among developed countries with regard to career choices among highly educated workers[1].

In the last few decades a complementary process between highly educated workers and technological breakthroughs has occurred: technological breakthroughs require highly educated workers, who in turn cause further breakthroughs in technology. A seminal work by Richard R. Nelson and Edmund S. Phelps (1966) is the first attempt to show the dynamic system that is consistent with these complementarities. In their model, education speeds the process of technological diffusion, and the rate of return to education is greater the more technologically progressive the economy. The recent economic growth model by Oded Galor and Omer Moav (2000), which explains wage inequalities between and among highly educated and less educated workers in the United States in the past few decades, is also based on these complementarities.

[1] This paper is not concerned with the behavior of high school graduates, nor the wage inequality between college graduates and high school graduates (i.e., college premium). See Yoshiaki Azuma (2000) for a theoretical investigation of the difference among developed countries with regard to college premium, skill-biased technological change, and firms' organizational structure. See also Yoshiaki Azuma and Herschel I. Grossman (2003) for a theoretical investigation of the inverse effect of skill-biased and ability-biased technological changes on college premium.

The basic structure of my analysis is similar to theirs, but my analysis focuses on the factors which cause the quantitative differences in the rate of technological progress among developed countries. The central idea in explaining the differences is the distinction between "specific" skills, which are the skills specific to a given firm, and "general" skills (i.e., commonly shared professional skills), which can be used across various firms[2].

In Japan many big companies rotate their regular workers in such a way that the workers are acquainted with a variety of job fields within the firm rather than with only a specialized technical job field. Their skills tend to be internally specific to a given firm and thus many workers choose to work under the long-term employment system. In the United States, in contrast, regular workers are normally responsible only for their own field of specialization. Their skills tend to be useful across firms and thus many workers choose to change their career. In general the proportion of highly educated workers who choose a career with a single company is much higher in Japan than in the United States.

The present paper constructs an overlapping-generations model that is consistent with this observation. The main focus is the choice of college graduates either to work under the long-term employment system (i.e., as a single-career worker) or to change their career either directly or indirectly through the pursuit of graduate education (i.e., as a multi-career worker) according to their lifetime incomes. We start from the static model, in which the proportion of multi-career workers to single-career workers is determined for a given rate of technological progress. Then the model is extended to a dynamic system that relates the labor force structure to economic growth.

The model considers several important characteristics that affect the level of skills each worker acquires. First, firm-specific skills depreciate as the speed of technological progress becomes higher. As we argue later, this characteristic stems from the fact that, in recent technological breakthroughs, firm-specific knowledge is less useful for dealing with the changing external technological environment. Second, workers differ in their level of cognitive ability and thus differ in their ability to acquire general skills. Third, compared to the choice of a

[2] These terms ("firm-specific" and "general") are based on the terms "specific training" and "general training" found in Gary S. Becker's seminal work on human capital. In Gary S. Becker (1975), for example,

> General training is useful in many firms besides those providing it; for example, a machinist trained in the army finds his skills of value in steel and aircraft firms, and a doctor trained (interned) at one hospital finds his skills useful at other hospitals. (p.19)
>
> Clearly some kinds of training increase productivity by different amounts in the firms providing the training and in other firms. Training that increases productivity more in firms providing it will be called specific training. Completely specific training can be defined as training that has no effect on the productivity of trainees that would be useful in other firms. Much on-the-job training is neither completely specific nor completely general…(p.26)

single-career path, the choice of a multi-career path causes the worker to acquire more general skills and fewer firm-specific skills over his total working life.

Given these three characteristics, the analysis in the static version of this model shows that the higher the rate of technological progress, the higher the level of general skills (and thus graduate education) in an economy. This result is consistent with Theodore W. Schultz (1975) who argues that the value of the ability to deal with disequilibria is high in a dynamic economy. Ann P. Bartel and Frank R. Lichtenberg (1987) empirically support the hypothesis that highly educated workers have a comparative advantage with respect to the adjustment to and implementation of new technology.

To extend the model to a dynamic system, we start with a discussion about the process of innovation. According to Joseph A. Schumpeter (1939), innovation is defined as the setting up of a new production function which covers the case of a new commodity as well as those of a new form of organization or a merger, or the opening up of new markets, and so on. Schumpeter (1939) also argues that innovation is possible without anything we should identify as invention and invention does not necessarily induce innovation, but produces of itself no economically relevant effect at all. In the recent technological breakthroughs with regard to information technology, however, the process of innovation requires entrepreneurs as well as their workers to be able to utilize the result of inventions made through cumulative basic research from various fields. Thus, the general skills of these entrepreneurs and workers have an advantage over specific skills in enhancing technological progress.

In sum, although an improvement in labor efficiency generally comes from utilizing either firm-specific skills or general skills, my analysis of technological breakthroughs assumes, as is consistent with Nelson and Phelps (1966), that an increase in the total level of general skills in an economy, which corresponds to an increase in the number of (more educated) multi-career workers, increases the rate of technological progress. This relationship connects the level of general skills in one period to the rate of technological progress in the next period. Thus the preceding static analysis is extended to a dynamic system that solves for the rates of technological progress over time.

In general, this dynamic system is explained as follows. First, an increase in the number of multi-career workers increases the total level of general skills in an economy. An increase in the total level of general skills, in turn, increases the speed of technological progress. This increase in the rate of technological progress lessens the value of skills learned within a firm, which causes fewer workers to choose to work under the long-term employment system. This positive feedback takes place in the development of breakthrough technological industries, and it captures a positive interaction between technological change and the return to workers on their cognitive abilities (i.e., ability-biased technological change).

The models also have an implication with regard to the differences in the rate of technological progress among countries. In the static version of the model, we see that for a given rate of technological progress, the advantage to a change in career, either with relatively higher gain from general skills or with relatively lower loss from firm-specific skills, results in a smaller number of workers who choose to work under the long-term employment system. Thus, at the steady-state equilibrium of the dynamic system, as well as in a transition to this equilibrium, we obtain the result that a higher advantage to a change in career results in a higher rate of technological progress.

However, this analysis is not enough to explain actual differences in the rate of technological progress among developed countries that have arisen because of career choices: If the number of multi-career workers is sufficiently large, then the promotion of career changes among highly educated workers not only increase the total level of general skills in an economy but also spread the benefits of one industry to others. For example, highly-skilled workers in the IT sector not only upgrade computer hardware and software or communication infrastructure, but also improve the efficiency of various types of industry through the improvement of search efficiency and the rationalization of various systems such as communication systems, distribution systems, inventory management systems, banking systems and so on.

Incorporating this external effect of career changes into the dynamic system, which takes place once the knowledge of information technology spills over from the breakthrough technological industries, the analysis shows the following results: if workers either acquire an insufficient number of firm-specific skills under the long-term employment system, or if they acquire a sufficiently large number of general skills when they go through a change of careers, then the number of multi-career workers in an economy becomes so large that some of them migrate among different types of industries, and an economy enjoys an additional rise in the speed of technological progress.

In contrast, if workers either acquire a sufficiently large number of firm-specific skills under the long-term employment system, or if they acquire an insufficient number of general skills even though they go through a change of careers, then an economy is trapped in a low rate of technological progress. This result obtains because, under these conditions, the proportion of multi-career workers in an economy is lower, and thus the knowledge arising from breakthrough technological industries remains within these same industries, and does not spill over into other types of industries.

This theoretical result is consistent with a recent empirical analysis by Dale W. Jorgenson and Kazuyuki Motohashi (2005), which quantifies the effect of information technology on Japan's TFP growth. In their analysis, the contribution of information technology is defined to include computers, software, and communications equipment. Other goods and services including those of IT-using industries are categorized as "non-IT." Given these definitions their analysis reveals, among other things, that the TFP growth rate in the whole Japanese economy fell after 1995, due to the slow TFP growth in the non-IT sector. The present paper suggests that initial labor force structures determine the respective paths of the rate of technological progress in the United States and Japan.

In the following section we present a basic analytical framework of an overlapping-generations model. In section 3 we set up and solve for a labor force structure for a given rate of technological progress. Section 4 introduces an endogeneity of the rate of technological progress and analyzes the relationship between labor force structure and technological progress. Section 4 also introduces an external effect of career changes and proposes a theoretical explanation of the prolonged slump of the Japanese economy. The final section concludes by discussing the policy implication and the robustness of the analysis.

2. Analytical Framework: Overlapping-Generations Model

2.1. Production of Final Output

Consider a small open overlapping-generations economy in a perfectly competitive world where economic activity extends over infinite discrete time. The assumption of a small open economy allows capital to flow instantaneously given a fixed world interest rate. In every period the economy produces a single homogeneous good that can be used for either consumption or investment. The production at period t, Y_t, is given by the conventional neoclassical constant-returns-to-scale production technology:

$$Y_t = F(K_t, A_t H_t) \equiv A_t H_t f(k_t); \quad k_t \equiv K_t/(A_t H_t), \tag{1}$$

where K_t and H_t represent the quantities of physical capital and the efficiency units of labor employed in production at period t, A_t represents the level of technology at period t with A_0 historically given, and k_t represents the quantity of capital per unit of effective labor at period t. The function $f(k_t)$ in equation (1) is both strictly monotonically increasing and strictly concave, which assures the existence of an interior solution to the producers' profit-maximization problem.

In the next section, the analysis focuses on college graduates' choice either to work under the long-term employment system (i.e., as a single-career worker) or to change their career in midstream (i.e., as a multi-career worker). These choices of individuals within a generation determine, in each period, the total number of efficiency units of labor in the economy. To simplify the analysis we assume that the types of labor supplied by single-career workers and multi-career workers are perfect substitutes as a labor input[3]. Specifically we assume that the total labor input H_t is the sum of the efficiency units of labor at period t of single-career workers, h_t^S, plus the units of multi-career workers, h_t^M:

$$H_t = h_t^S + h_t^M . \tag{2}$$

The stock of physical capital in each period is given by the sum of the economy's aggregate saving, net of international lending.

Producers operate in a perfectly competitive environment. Given the wage rate per efficiency unit of labor and the rate of return to capital at periods t, w_t and r_t respectively, producers choose the quantities of physical capital at period t, K_t, and the efficiency units of labor at period t, H_t, so as to maximize profits. Thus the producers' inverse demand for factors of production is derived as follows:

$$\begin{aligned} r_t &= f'(k_t); \\ w_t &= A_t[f(k_t) - f'(k_t)k_t] \equiv A_t w(k_t). \end{aligned} \tag{3}$$

Suppose that the world rental rate is stationary at level $\bar{r}$. Since the small open economy permits unrestricted international lending and borrowing, its rental rate is stationary as well at rate $\bar{r}$. Namely, $r_t = \bar{r}$. Consequently, the quantity of capital per unit of effective labor in every period t, k_t, is stationary at the level $f'^{-1}(\bar{r}) = \bar{k}$, and the wage rate per unit of effective labor is $w_t = A_t w(\bar{k}) = \bar{w} A_t$.

[3] The introduction of imperfect substitution between these two types of labor, as well as between specific skills and general skills in equation (4), would not change the qualitative analysis. It would, however, make the analysis complex and less transparent. See Oded Galor and Omer Moav (2000) for a similar analysis made between skilled and unskilled labor.

2.2. Demand for Final Output

In each period a new generation is born. It consists of a continuum of individuals of measure one. Individuals, within as well as across generations, are identical other than in level of cognitive ability. For simplicity we assume that in each generation ability is distributed uniformly over the unit interval.

Individuals live for two periods. In the first period, individuals choose either to work under the long-term employment system or to change their career in midstream. The resulting wage income is allocated between consumption and saving. In the second period individuals retire and consume their entire savings. Individuals' preferences are defined by their consumption over the two periods of their lives. They are represented by a utility function that is strictly monotonically increasing, strictly quasi-concave, which assures the existence of an interior solution for the utility maximization problem.

3. Labor Force Structure for a Given Rate of Technological Progress

3.1. Firm-Specific Skills and General Skills

In this paper, labor force structure refers to the proportion of workers who choose a single-company career vs. those who choose a multi-career path among several firms. This section starts with college graduates' choice either to work under the long-term employment system (i.e., as a single-career worker) or to change their career either directly or indirectly through the pursuit of graduate education (i.e., as a multi-career worker) according to their expected incomes. To simplify the analysis, the model assumes that all college graduates start the first period of their life under the long-term employment system. The model also abstracts from the expense of graduate education.

As discussed in the introduction, the paper assumes that each worker has the following two types of skills. One type is "firm-specific" skills which are internally specific to a given firm, and the other is "general" skills which can be used across various firms. The model also considers several important characteristics that affect the level of skills each worker acquires. First, firm-specific skills depreciate as the speed of technological progress becomes higher. Second, workers differ in their level of cognitive ability and thus differ in their ability to acquire general skills. Third, compared to the choice of a single-career path, the choice of a multi-career path causes the worker to acquire more general skills and fewer firm-specific skills over his total working life.

In order to capture all these characteristics in a tractable way we assume that h_t^{ji} in equation (4) represents the efficiency units of labor at period t of the worker i who chooses a single-career path (i.e., $j=S$) or a multi-career path (i.e., $j=M$):

$$h_t^{ji} = \alpha^j (1 - \delta g_t) + \beta^j a^i. \tag{4}$$

In equation (4), $\alpha^j(1-\delta g_t)$ and $\beta^j a^i$ are the total magnitude in efficiency units of specific skills and general skills, respectively, that the worker i supplies in the first period of his life. Both α^j and β^j are constant terms for a given career path. Compared to the choice of a single-career path, the choice of a multi-career path causes the worker, over his total working life, to acquire more general skills, namely $\beta^M > \beta^S$, but fewer specific skills, namely $\alpha^M < \alpha^S$. Cognitive ability a^i is measured in efficiency units and is distributed uniformly between 0 and 1. Due to the heterogeneous distribution of cognitive ability, the size in efficiency units of general skills of the worker with a^i is represented as $\beta^j a^i$. The symbol $g_t \equiv (A_t - A_{t-1})/A_{t-1}$ represents the rate of technological progress from period $t-1$ to period t, and δ measures the degree of depreciation. Due to technological progress, specific skills are subject to depreciation and the size becomes δg_t times smaller than α^j.

3.2. Workers' Choices of their Career Paths

Assume that each individual chooses his career path depending on which career path results in more lifetime income. Remember that individuals prefer to maximize consumption over the two periods of their lives, and that utility strictly increases with consumption. Since the only source of income of each worker comes through work in the first period, maximizing his income in the first period is a necessary condition for maximizing his utility.

The income in period t of individual i who chooses either a single career path ($j=S$) or a multi-career path ($j=M$) is given by $I_t^{ji} \equiv h_t^{ji} w_t$. As the following figure shows, there exists an individual whose choice of career path is independent of income.

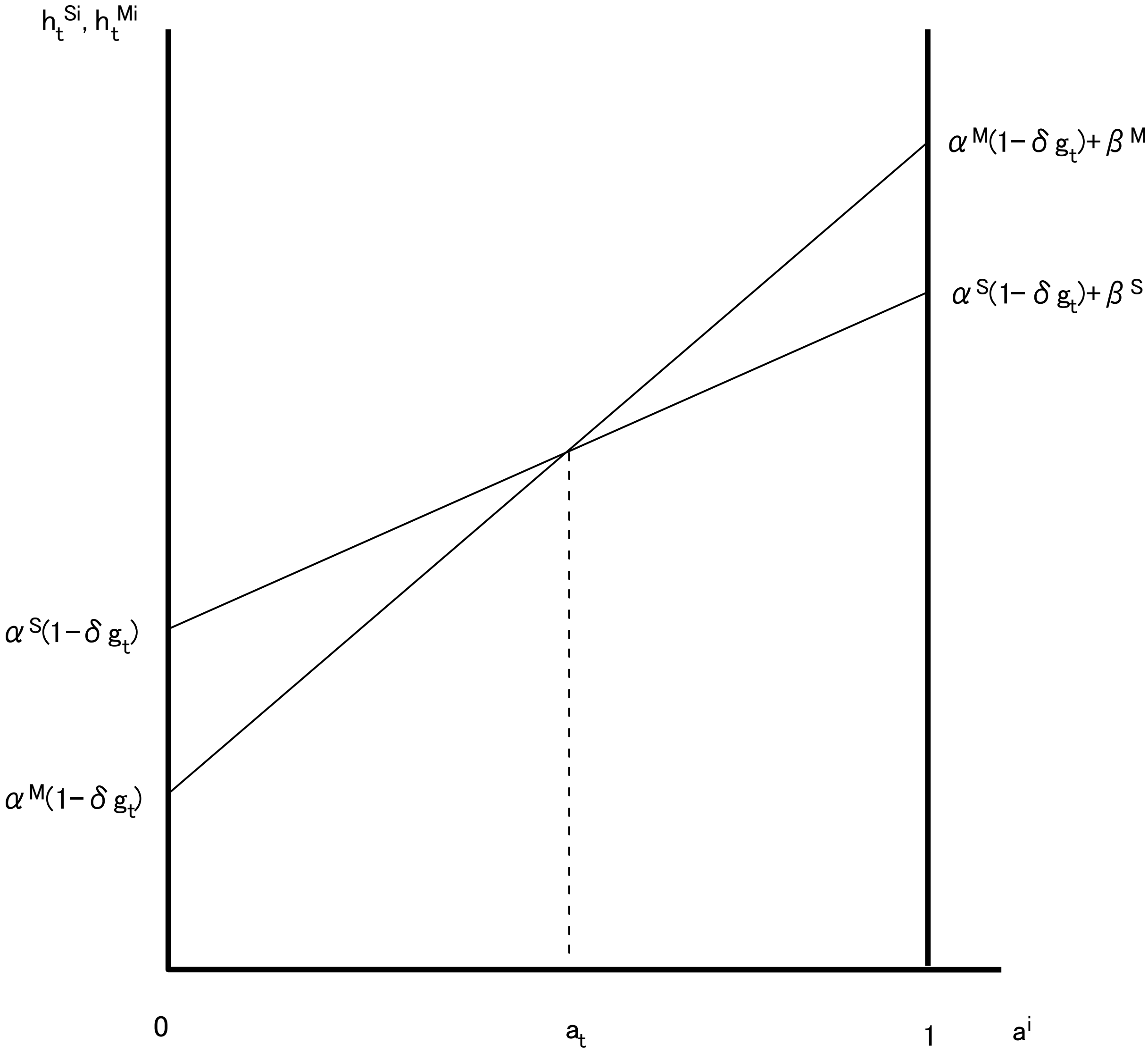

Figure 1: Labor Force Structure for a Given Rate of Technological Progress

Specifically, a_t in figure 1 is the value of a^i that satisfies $I_t^{Si} = I_t^{Mi}$:

$$a_t = \Phi(1-\delta g_t), \tag{5}$$

where $1/\Phi \equiv (\beta^M - \beta^S)/(\alpha^S - \alpha^M)$ measures the advantage to a change in career and we assume $1/\Phi > 1-\delta g_t$ for a_t to be less than one.

All individuals whose cognitive ability is less than the value of a_t choose to work under the long term employment system, whereas all individuals with the value of more than a_t choose the multi-career path. Remember that the number of the population is assumed to be one. Hence

a_t in equation (5) represents the fraction of the population in period t who choose to work under the long-term employment system.

From equation (5) we see that the higher the rate of technological progress the smaller the number of workers who choose to work under the long-term employment system. This result obtains because individuals accumulate more firm-specific skills under the long-term employment system and technological progress causes the loss of these skills. Hence a worker who would otherwise be indifferent to career change will be motivated to consider a career in a new firm. A resulting increase in the number of multi-career workers brings an increase in the total number of general skills in an economy.

Equation (5) also shows that $1/\Phi$, which measures the advantage to a change in career, affects the number of multi-career workers in an economy. Specifically, a lower Φ, either with relatively higher gain from general skills or with relatively lower loss from firm-specific skills, results in a larger proportion of multi-career workers. From a historical point of view, the United States has relatively lower Φ than Japan. One possible explanation is that the United States has been a technological leader and Japan has been a follower for a long period of time. After World War II, for example, Japan treated the United States as the ideal model for its economy.

If a country has been a technological leader and thus it does not have a model for imitation or innovation[4], then technological progress will be mainly driven by major breakthroughs in technology. Thus, a change in career, in the long run, provides workers a larger gain from acquiring general skills and causes a smaller loss from losing firm-specific skills. In equation (5) the United States has a relatively lower value for Φ. In this case capable workers are allocated primarily to their respective specialized fields, and thus the economy as a whole has a larger proportion of multi-career workers.

In contrast, if a country has been a technological follower and thus it has another country as a model for imitation or innovation, then firms take advantage of specific skills to improve existing technologies. Thus, a change in career causes workers a greater loss from losing firm-specific skills and provides a smaller gain from acquiring general skills. In equation (5) Japan has a relatively higher value for Φ. In this case single-career workers in a job rotation system can work more productively than skill-specialized multi-career workers, and thus the economy as a whole has a larger proportion of single-career workers.

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[4] The distinction between innovation and imitation is important in the analysis of the (very) long run, where we normally analyze the technological gap between developed and developing countries. See, for example, Susanto Basu and David N. Weil (1998) on their analysis about appropriate technology.

4. Career Changes and Technological Breakthrough

4.1. Endogenous Technological Change

The preceding static analysis shows that the rate of technological progress in a given period, ceteris paribus, determines the level of general skills in that same period. In this section, this static analysis is extended to a dynamic system that solves for the rates of technological progress over time. To understand the background of this analysis, we recall the discussion in the introduction about the process of innovation.

In the recent technological breakthroughs in information technology, the process of innovation requires entrepreneurs as well as their workers to utilize the result of inventions made through cumulative basic research from various fields. Thus, general skills have an advantage over specific skills in enhancing technological progress. Accordingly, although an improvement in labor efficiency generally comes from utilizing either firm-specific skills or general skills, my analysis of technological breakthroughs assumes that an increase in the total level of general skills in an economy increases the rate of technological progress. Remember that in this framework, all workers have their own general skills, and the larger the number of (more educated) workers with a multi-career path the higher the total level of general skills is in an economy. As is consistent with these observations, we assume the following linear equation that negatively correlates the rate of technological progress $g_{t+1} \equiv (A_{t+1} - A_t)/A_t$ with the number of single-career workers in an economy, a_t:

$$g_{t+1} = \lambda\,(1 - a_t) + \theta\, a_t\,. \tag{6}$$

In equation (6) λ and θ represent the increase in the rate of technological progress resulting from a one-unit increase in the number of multi-career workers and single-career workers respectively, and we assume $\lambda > \theta$.

Combining equation (6) with (5) we solve for a_{t+1} as a function of a_t:

$$a_{t+1} = \Phi\,[\,(1 - \delta\,\lambda) + \delta\,(\lambda - \theta)\,a_t\,]\,. \tag{7}$$

The following figure shows the phase diagram of this equation.

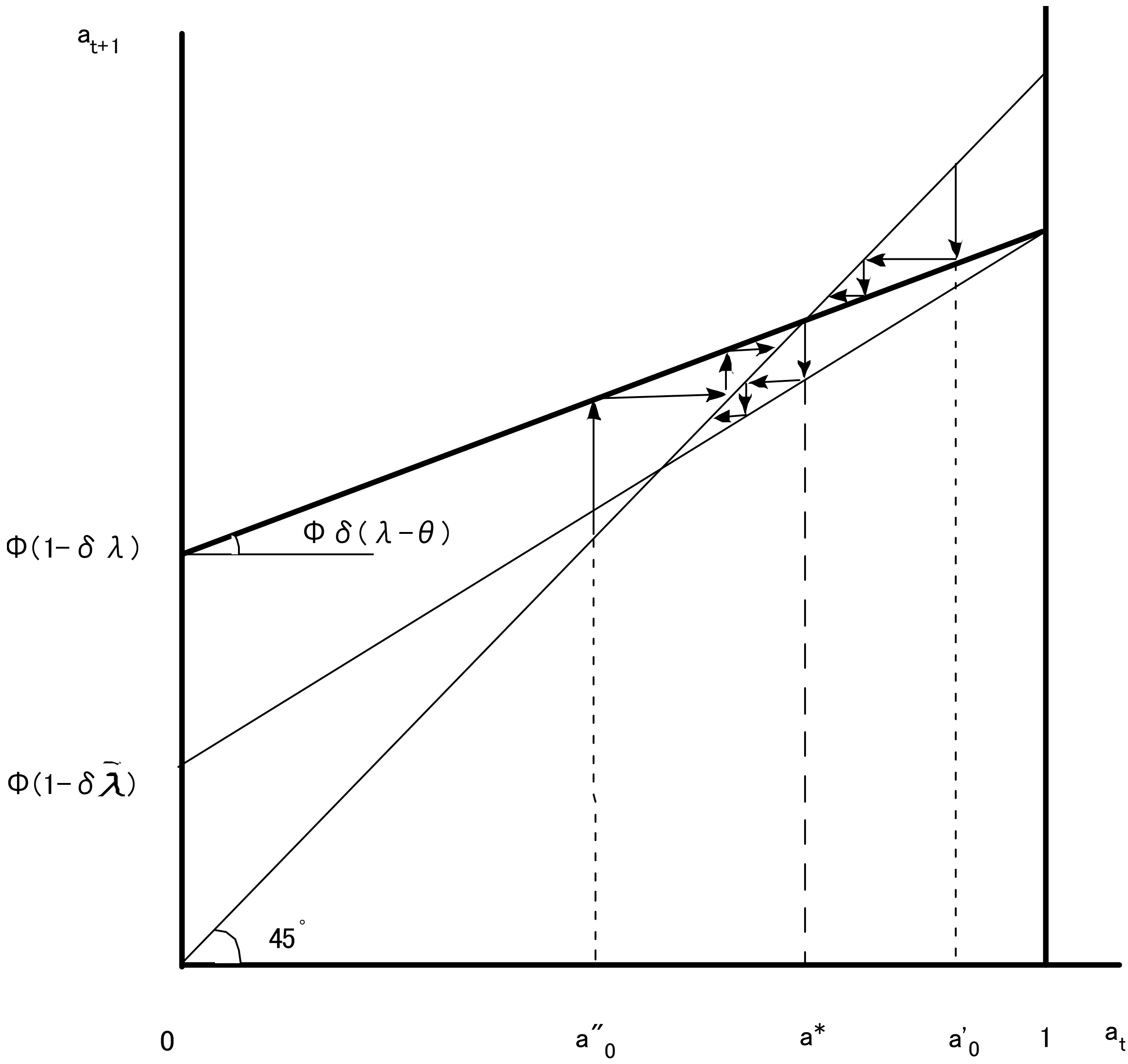

Figure 2: A Transition to a Steady-state Equilibrium with Perpetual Growth

In figure 2, $a*$ is a steady-state level of a_t and it is stable over the unit interval. Also recall that from equation (5) g_t corresponds inversely one-to-one with a_t. Hence, if a_0 is more than $a*$, say a'_0 in figure 2, then we observe a monotonic increase in the rate of technological progress in a transition to the steady-state equilibrium. In contrast, if a_0 is less than $a*$, say a''_0, then we observe a monotonic decrease in the rate of technological progress in a transition to the steady-state equilibrium. In both cases the rate of technological progress is always positive.

Now suppose that the complementarity between general skills and the rate of technological progress becomes higher. Specifically, λ in equation (6) becomes higher. Since the partial derivative of a_{t+1} with respect to λ in equation (7) is negative, we have a monotonic increase in the rate of technological progress in a transition to a steady-state equilibrium with perpetual growth. This result is confirmed in figure 2 where we have $\lambda < \tilde{\lambda}$. The intuition behind this positive feedback loop is explained as follows. First, an increase in the number of multi-career workers increases the total level of general skills in an economy. An increase in the total level of general skills, in turn, increases the speed of technological progress. An increase in the rate of technological progress then lessens the value of skills learned within a firm, which causes fewer workers to choose to work under the long-term employment system.

Equation (7) also shows that at the steady-state equilibrium, as well as in a transition to this equilibrium, both the proportion of multi-career workers and the rate of technological progress are higher as the advantage to a change in career, $1/\Phi$, becomes higher. We also notice that both g_t and A_t increase in the transition. Thus, equations (3) and (4) imply that the incomes of some workers with lower cognitive abilities may decrease in the transition. Once an economy reaches a steady-state equilibrium, however, incomes of all workers increase. This result obtains because in the steady-state equilibrium, g_t is a positive constant and thus only A_t increases over time.

4.2. The Japanese Trap

The preceding subsection analyzes the development of breakthrough technological industries through a positive interaction between general skills and the rate of technological progress. But this analysis is not enough to explain actual differences in the rate of technological progress that have arisen among developed countries because of career choices: If the number of multi-career workers is sufficiently large, then the promotion of career changes among highly educated workers not only increases the total of general skills in an economy but also spread the benefits of one industry to others. For example, highly-skilled workers of the IT sector not only upgrade computer hardware and software or communication infrastructure, but also improve the efficiency of various types of industry through the improvement of search efficiency and the rationalization of various systems such as communication systems, distribution systems, inventory management systems, banking systems and so on. This external effect takes place once the knowledge of information technology spills over from the breakthrough technological industries.

Suppose that $1-\overline{a}$ is the minimum number of multi-career workers that is required to cause this external effect. Below this number the knowledge spills over only among the breakthrough technological industries and causes an upgrade of the new technology. But once the actual number exceeds this minimum number, then some multi-career workers migrate among different types of industries and thus new technology is applied to other industries, which causes an additional rise in the speed of technological progress. Now equation (6) is represented as follows:

$$g_{t+1} = \lambda^{z}(1-a_t) + \theta\, a_t,\ z = L, H \text{, and}$$

$$\text{if } (1-a_t) < (1-\overline{a}) \text{, then } \lambda^{z} = \lambda^{L} \equiv \lambda \text{, and}$$

$$\text{if } (1-a_t) \geq (1-\overline{a}) \text{, then } \lambda^{z} = \lambda^{H} \equiv \lambda + \gamma, \qquad (8)$$

where $\gamma > 0$ represents the contribution of the external effect to the increase in the rate of technological progress resulting from a one-unit increase in the number of multi-career workers. The assumption $\lambda > \theta$ in equation (6) is replaced with $\lambda^{H} > \lambda^{L} > \theta$. The corresponding phase diagram is shown in figures 3 and 4, where the advantage to a change in career, $1/\Phi$, is smaller in figure 3 than in figure 4, given other parameter values remaining constant. Figures 3 and 4 correspond to the Japanese and US economies, respectively.

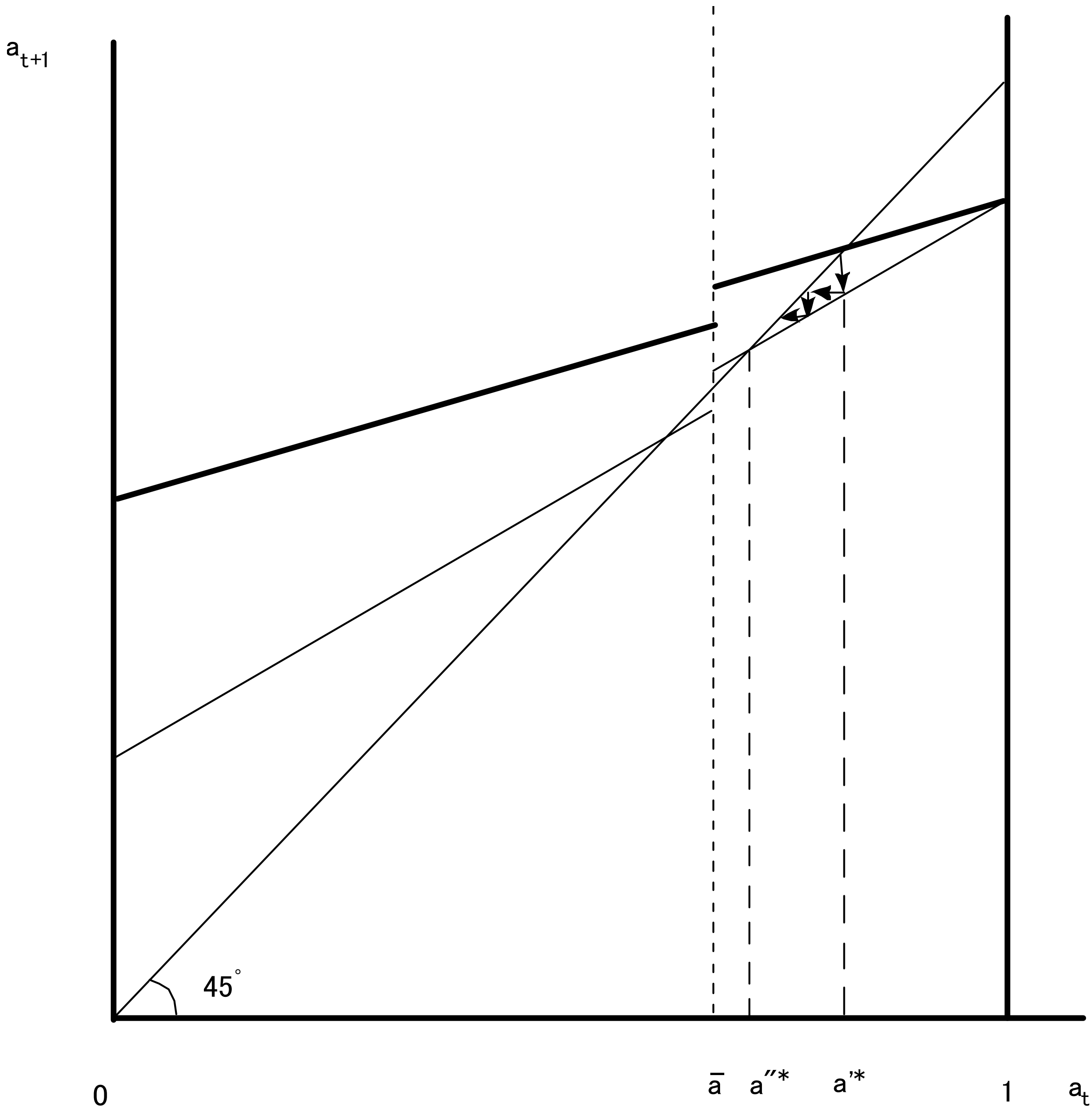

Figure 3: The Growth of the Rate of Technological Progress in the Japanese Economy

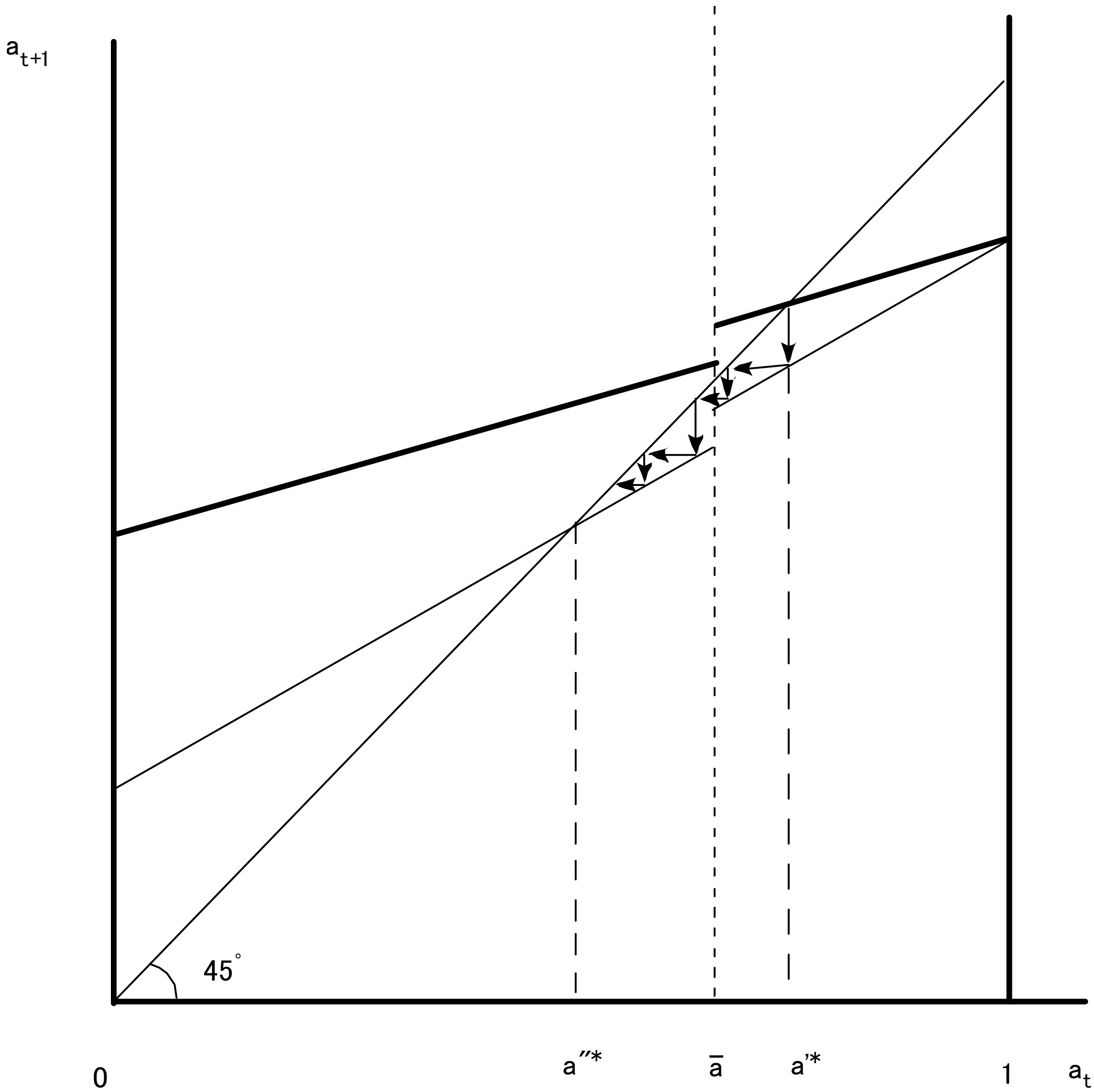

Figure 4: The Growth of the Rate of Technological Progress in the US Economy

Now again suppose that the complementarity between general skills and the rate of technological progress becomes higher. Specifically, λ in equation (8) becomes higher. Depending on the parameter values of δ, γ, λ, θ and Φ, we have either a larger number of single-career workers with $\lambda = \lambda^L$ shown in figure 3 or a larger number of multi-career workers with $\lambda = \lambda^H$ shown in figure 4. As figure 3 shows, if parameter values are such that an initial economy has a sufficiently larger number of single-career workers, then the benefit of the technological progress spills over only among the breakthrough technological industries. In contrast, if parameter values are such that an initial economy has a sufficiently larger number of multi-career workers, as depicted in figure 4, then the benefit spills over to other types of industries and thus attains a higher rate of technological progress. Hence the analysis shows that initial labor force structure, combined with the recent technological breakthrough, determines the respective paths of the rate of technological progress in the United States and Japan.

5. Concluding Remarks

The present paper asks, within a macroeconomic framework, why information technology in Japan has not been applied broadly to enhance the productivity of other substantially related industries. The answer comes from career choices among highly educated workers: Japanese economic structures, including the labor market, firms' organization, and the educational system, all favor the development of firm-specific skills; thus the proportion of highly educated workers who choose a single-career path is higher in Japan. This structure probably works well within the manufacturing sector, but from the standpoint of the overall economy it now also puts the service sector in a trap.

This analysis implies that a partial restructuring of the Japanese economy alone cannot achieve recovery from the slump. For example, a governmental structural policy which enhances labor mobility will not achieve recovery without a shake-up in the long-term employment system among highly educated workers, especially in the manufacturing sector, that encourages these highly educated workers to migrate between sectors. Although there has been an increase in labor mobility since the 1990s in Japan, this primarily reflects a decrease in the number of full-time regular employees among the less educated. With regard to government policy which enhances basic research in academic fields, such as through the expansion of graduate schools, this will not stimulate technological progress without a decrease in the proportion of highly educated workers who choose a single-career path. Any new structural policy should take into account the mutual interaction among the manufacturing sector, the service sector, and graduate education, with the aim of encouraging mobility of highly educated workers.

In the model used in this paper, the migration of highly educated workers plays a key role in conveying the knowledge of new technology from one sector to another. Nevertheless, any newly invented technologies should sooner or later prevail and become accessible to all sectors. In that stage of technological development, it might be possible for firms to innovate and achieve efficiency with lower costs by using their firm-specific skills. Thus, from the long-term perspective, one would hope that the Japanese service sector, which has not been technologically efficient for a long period of time, might be able to enhance its productivity without a change in the high proportion of single-career workers in the economy. The question to ask then becomes how long the long run is, since we have already spent nearly twenty years living with low income growth.

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