

Japan's Lost Decade Revisited: Total Factor Productivity and Economic Growth

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This paper examines the decade-long economic slump in Japan during the 1990s. In the neoclassical growth framework, a fall in total factor productivity growth is expected to slow down the economy's long-term growth. This paper's findings based on the Malmquist index show that Japan's productivity growth rate in the 1990s is not only historically low but also lags considerably behind the contemporaneous growth rates in other OECD nations. Building upon the Japanese experience, this paper considers policy responses to the current global financial crisis.

Keywords: *Japan, Economic growth, Total factor productivity, Malmquist index*

1. INTRODUCTION

When a number of countries pursued expansionary fiscal and monetary policies in the wake of the 2008 financial crisis, ubiquitous references were made to what had happened to Japan in the 1990s. In discussions of this so-called lost decade, the persistent economic slump was typically blamed on the weak demand. Inadequate fiscal and monetary policies were believed to have exacerbated such weaknesses.¹ The problems with financial intermediation in the country's weak banking sector were also argued to have contributed to the slump by pulling corporate investment below its optimal level and hence, again, by depressing aggregate demand.

However, recent studies increasingly question the validity of the thesis of sub-optimal investment. Ando, Christelis, and Miyagawa (2003) provide empirical evidence in support of the over-investment, rather than the under-investment, of Japanese corporations in the 1990s. Hayashi (2004) empirically verifies this over-investment argument by using more updated data from the Japanese National Accounts. These findings strongly suggest that demand side developments may account for business cycles but may not be entirely relevant for explaining the chronic decade-long economic slump.

How would the over-investment hypothesis marry with Japan's decade-long output slump? The neoclassical growth framework provides a clue. In the standard neoclassical model with exogenous total factor productivity (TFP) that dates back to Solow (1956) and Swan (1956), a fall in the TFP growth rate reduces the pace of the steady-state growth, and raises the steady-state capital-output ratio. This appears to be in line with a significant capital deepening and a decline in the after-tax rate of return that have been observed in Japan during the 1990s.

A noticeable drop in Japan's TFP growth in the 1990s is well-documented in previous studies, including Hayashi and Prescott (2003) among others, but they tend to invariably use

¹ See Posen (1998), Mikitani and Posen, eds. (2000), and Krugman (1998), among others. In contrast, Katz (1998), Vogel (1996), and Carlile and Tilton, eds. (1998) emphasize the country's structural problems in their discussions of the Japanese economy.

growth accounting in estimating TFP changes. The growth accounting approach implicitly assumes that all units of production are technically efficient. This may be a reasonable assumption for the U.S. economy which has led technological development and therefore been considered the world's most efficient economy over the past half-century. However, most economies, including Japan, have tried to catch up with the U.S. economy most of time, although admittedly, they have demonstrated the world's best practices in some areas. Subsequently, complete technical efficiency is not a realistic assumption for estimating Japan's TFP changes. This paper thus uses the Malmquist index approach proposed by Caves et al. (1982) that allows for technical inefficiency in estimating TFP growth rates.

In Section 2, this paper develops a standard growth model to examine the Japanese economy. Section 3 outlines the Malmquist index and its decomposition. This is then followed by a discussion on the data and estimation results in Section 4. The last section is the conclusion with some remarks.

2. GROWTH MODEL

The standard growth framework clearly illustrates how it was possible for Japan to suffer prolonged economic slump when the economy was plagued, not by under-investment but instead by excessive capital formation beyond the optimal level, as argued by Ando et al. (2003) and Hayashi (2004). This paper adopts a standard neoclassical model with a constant, exogenous saving rate that traces back to Solow (1956) and Swan (1956).² The aggregate production function is assumed to be described by the Cobb-Douglas function,

$$Y_t = A_t K_t^\alpha L_t^{1-\alpha} \quad (1)$$

where Y is aggregate output, K is aggregate capital, and L is total employment. $A > 0$ is the level of TFP and α is a constant with $0 < \alpha < 1$.

For simplicity, we suppose that the economy is closed and there are no government expenditures on goods and services. Hence, the aggregate output is either consumed or invested in this economy. Investment is used to create new units of capital which depreciates at the constant rate $\delta > 0$. In addition, we assume that a constant fraction of the aggregate output is saved at the rate of s ($0 \leq s \leq 1$). We also assume that total employment grows at a constant, exogenous rate of $n \geq 0$.

Eq. (1) can be rewritten in intensive form as

$$y_t = A_t k_t^\alpha \quad (2)$$

where $y \equiv Y/L$ and $k \equiv K/L$.

The steady-state value of k for the given level of TFP, A_τ , is denoted as \bar{k}_τ , and satisfies the condition

$$s A_\tau \bar{k}_\tau^\alpha = (n + \delta) \cdot \bar{k}_\tau \quad (3)$$

If k is below \bar{k}_τ , k is expected to increase over time until it reaches \bar{k}_τ . The growth rate of

² For a more detailed exposition of this framework, see Barro and Sala-i-Martin (2004).

k at t along the transition is characterized by

$$\dot{k}_t/k_t = sA_\tau k_t^{-(1-\alpha)} - (n + \delta) \quad (4)$$

From Eq. (4), the growth rate of k falls as k increases and it approaches 0 as k approaches \bar{k}_τ . Using Eq. (3), the growth rate of k at t along the transition can also be expressed as

$$\dot{k}_t / k_t = (n + \delta) \cdot \left[\left(\frac{k_t}{\bar{k}_\tau} \right)^{\alpha-1} - 1 \right] \quad (5)$$

Subsequently, the economy's optimal rate of growth in capital per worker at t depends on the distance between the t period level of capital per worker, k_t , and its steady-state level, \bar{k}_τ . From Eq. (3), \bar{k}_τ in turn depends crucially on the level of TFP, A_τ . For example, an improvement in TFP will raise the steady-state level of capital per worker when the economy's saving rate, depreciation rate, and employment growth rate remain constant. Since a higher level of TFP would shift the country's steady-state position farther away, the TFP growth is expected to increase the distance between the current and steady-state levels of capital per worker, and hence the optimal rate of growth in capital per worker. Therefore, the TFP growth has not only long run implications for economic growth by altering the long run or steady-state level of capital per worker, but also has immediate effects on the current pace of economic growth through its influence on the current growth rate of capital per worker.

Using our growth model, we can now find a clue to understand how Japan suffered economic slump throughout the 1990s while it continued to over-invest. Suppose that Japan experienced a persistent stagnation in the TFP growth during the 1990s. Then, according to the model, it is possible that the country's economic growth was languishing at a relatively low rate even with the over-investment because the optimum rate of capital accumulation had become already too low, due to the stagnant TFP growth. In fact, our growth model indicates that excessive investment can temporarily boost capital accumulation and economic growth above the optimum rate, but then it quickly undermines future growth by accelerating the reduction of the distance between the current and steady-state levels of capital per worker.

3. THE MALMQUIST INDEX APPROACH

TFP growth is typically assumed to reflect technological progress. Technological progress includes not only innovations in both the products and the processes, but also any government policies and institutional changes that affect the position of the production function. This paper attempts to empirically measure TFP growth based on the Malmquist index approach.

In the Malmquist index approach, a sample of countries is chosen to construct the best-practice frontier using input-output combinations of the sample countries, and measure the distance between any particular observation and the frontier. This study draws on a sample of the members of the Organization for Economic Cooperation and Development (OECD) for building the best-practice frontier. In line with Shephard (1970) and Caves et al. (1982), we define the output distance function at t , $D'_{0,t}$, as follows:

$$D_0^t(X_t, Y_t) = \inf \{ \theta : (X_t, Y_t / \theta) \in T^t \} \quad (6)$$

where T^t denotes the production technology which is defined as $T^t = \{(X_t, Y_t) : X_t \text{ can produce } Y_t \text{ at time } t\}$. X_t is a vector of inputs at t , (K_t, L_t) , and Y_t is aggregate output at t . Note that $D_0^t \leq 1$ signifies $(X_t, Y_t) \in T^t$ with (X_t, Y_t) lying on the best-practice frontier when $D_0^t = 1$.

Using the output distance function described in Eq. (6), we define the output-based Malmquist index for an individual country between period t and period $t + 1$ as³

$$M_0(X_{t+1}, Y_{t+1}, X_t, Y_t) = \left[\frac{D_0^t(X_{t+1}, Y_{t+1})}{D_0^t(X_t, Y_t)} \frac{D_0^{t+1}(X_{t+1}, Y_{t+1})}{D_0^{t+1}(X_t, Y_t)} \right]^{1/2} \quad (7)$$

A value of M_0 greater than 1 indicates positive growth of TFP from period t to period $t + 1$, and a value less than 1 represents a decline in TFP. TFP growth as measured this way has some desirable features. Most importantly, the Malmquist index approach allows for technical inefficiency by building on the concept of the best-practice frontier. This is not the case with the Törnqvist-index formulation of the growth accounting approach.

With the possibility of technical inefficiency, a country's TFP changes may not be solely driven by progress in available production technologies – summarized as OECD best practices in our analysis – but also by the country's capacity to keep up with the existing best practices. To show this point more formally, we rewrite Eq. (7), following Färe et al. (1994), as

$$M_0(X_{t+1}, Y_{t+1}, X_t, Y_t) = \frac{D_0^{t+1}(X_{t+1}, Y_{t+1})}{D_0^t(X_t, Y_t)} \times \left[\frac{D_0^t(X_{t+1}, Y_{t+1})}{D_0^{t+1}(X_{t+1}, Y_{t+1})} \frac{D_0^t(X_t, Y_t)}{D_0^{t+1}(X_t, Y_t)} \right]^{1/2} \quad (8)$$

Eq. (8) shows that the Malmquist index can be broken down into two basic components – “technical change” and “efficiency change”. Each ratio inside the bracket on the right hand side of Eq. (8) measures a shift in the best-practice frontier estimated at the input level in each of period t and period $t + 1$, and the geometric mean of these two shifts represents “technical change” from period t to period $t + 1$. The first ratio on the right hand side of Eq. (8) represents “efficiency change” measuring the change in technical efficiency from period t to period $t + 1$. Subsequently, “efficiency change” determines whether production is moving closer to or away from the prevailing frontier, and captures the efficiency catch-up effect between the two periods t and $t + 1$. The value of “efficiency change” greater than 1 implies that the country has closed the gap of its production method with the prevailing best practice.

4. DATA AND ESTIMATION RESULTS

In order to estimate Japan's TFP changes based on the Malmquist index, a sample of OECD countries was chosen to construct the best-practice frontier. The final sample consists of 22 OECD countries for which the data on GDP, non-residential fixed capital formation, and total employment are available over the period of 1980-2006 from the OECD.Stat. They

³ This follows Caves et al. (1982).

Table 1. Malmquist Index, Technical Change, and Efficiency Change in Japan

	Malmquist Index	Technical Change	Efficiency Change
1981	1.017	0.992	1.025
1982	1.013	0.998	1.015
1983	0.997	1.026	0.971
1984	1.022	1.045	0.977
1985	1.039	1.014	1.025
1986	1.014	1.061	0.956
1987	1.018	1.006	1.012
1988	1.042	1.034	1.007
1989	1.02	1.045	0.976
1990	1.015	1.005	1.009
1991	0.996	1.038	0.96
1992	0.981	0.98	1.001
1993	0.985	1.02	0.965
1994	0.999	1.001	0.998
1995	1.011	0.982	1.03
1996	1.018	0.987	1.031
1997	1.001	1.023	0.979
1998	0.978	1.014	0.965
1999	1	1.029	0.973
2000	1.027	1.018	1.009
2001	1.002	0.971	1.032
2002	1.01	1.003	1.007
2003	1.015	0.993	1.022
2004	1.025	1.02	1.005
2005	1.015	1.016	0.999
2006	1.019	1.014	1.005

include: Australia, Austria, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Turkey, the United Kingdom, and the United States. Among the current OECD member countries, 8 countries were excluded due to data unavailability; they include Belgium, the Czech Republic, Hungary, Mexico, New Zealand, Poland, the Slovak Republic, and Switzerland.

Our measure of aggregate output is constant price GDP adjusted in 2000 prices. The two aggregate input proxies are total employment and the fixed capital stock. Total employment is defined as the number of workers, and the fixed capital stock is the cumulated and depreciated sum of past investment. The fixed capital stock does not include residential construction, and is calculated from gross fixed capital formation – adjusted in 2000 prices as well – using the perpetual inventory method with the depreciation rate of 10 percent.⁴ The fixed capital stocks and GDP of individual countries are all converted to U.S. dollars using the purchasing power parity (PPP) exchange rate from the OECD.Stat.

⁴ Alternative measures of the fixed capital stock were also calculated assuming different rates of depreciation. However, they provided a similar pattern.

Table 2. Average TFP Growth

		1981 - 1990	1991 - 2000	2001 - 2006
Japan	Malmquist Index	1.02	0.999	1.014
	Technical Change	1.022	1.009	1.003
	Efficiency Change	0.997	0.991	1.012
US	Malmquist Index	1.005	1.012	1.009
	Technical Change	1.011	1.019	1.007
	Efficiency Change	0.994	0.994	1.002
OECD*	Malmquist Index	1.01	1.007	1.007
	Technical Change	1.012	1.018	1.004
	Efficiency Change	0.998	0.991	1.003

* Australia, Austria, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Turkey, the United Kingdom, the United States.

For estimation of the best-practice frontiers, this paper employs the data envelopment analysis (DEA) approach. With the DEA approach, the best-practice frontiers are estimated by non-parametric linear programming methods. We assume constant returns to scale (CRS) as underlying technology and calculate Malmquist indexes. Variable returns to scale (VRS) may be an alternative specification of technology, but the Malmquist index is equivalent to the traditional notion of TFP under a CRS specification (Färe et al. 1997; and Ray and Desli 1997). For calculation of indexes, we use DEAP version 2.1 (Coelli 1996).

Table 1 summarizes Japan's Malmquist indexes and their decomposed indexes, technical changes and efficiency changes, over the period 1981-2006. According to calculations of the Malmquist index, the country's TFP growth slowed down considerably during the 1990s. While TFP grew at an average of 2 percent per year over the 1981-1990 period, it did not improve at all on average and often deteriorated during the 1990s. The geometric mean of Japan's Malmquist indexes for 1991-2000 amounts to 0.999 which is less than 1.

Table 2 shows that Japan's TFP performance stood out in the OECD region in the 1980s as well as 1990s, but for different reasons. During 1981-1990, Japan's TFP growth was particularly strong compared to the OECD average of 1 percent per year. However, the country's virtually stagnant TFP growth in the 1990s was lagging conspicuously behind the OECD average growth in the same period. Therefore, a fall in Japan's TFP growth during the 1990s appears more striking against a backdrop of the OECD average performance. The extent of the slowdown becomes even more dramatic when Japan's TFP changes are compared to the changes in the United States. Japan outperformed the U.S. in terms of TFP growth by an annual average of 1.5 percent points in the 1980s, but the country's TFP growth fell behind that of the U.S. by almost the same percentage points during the 1990s.

Table 2 also suggests that the Japanese economy was experiencing a rise in technical inefficiency in the 1980s, and this rising inefficiency was further accelerated in the 1990s. The averages of efficiency changes less than 1 indicate that Japan was on the trend of moving away from the best-practice frontier over those two decades. However, the country appears to have turned around and closed its gap with the best-practice frontier considerably

in 2001-2006. Largely due to this robust improvement in technical efficiency, Japan achieved a respectable TFP growth of 1.4 percent per annum on average, over the same period.

This rate of TFP growth was still short of the rate that country had managed to register in the 1980s, but significantly surpassed the contemporaneous TFP growth of the OECD area as a whole and that of the U.S. in particular. This remarkable turnaround in TFP growth over 2001-2006 can be partly explained by various economic reforms implemented under the premiership of Junichiro Koizumi. For example, the Koizumi administration managed to sever the vicious cycle of "*oikashi*" – the practice of "evergreening" bad loans – by successfully putting an end to the non-performing loans problem. The prevalence of "*oikashi*" in the 1990s obviously dragged down the country's TFP throughout the decade by hampering the much needed exit of inefficient firms which effectively blocked the entry of more efficient firms.

5. CONCLUSION

The estimates of Japan's TFP growth based on the Malmquist index approach tends to confirm the picture painted by TFP residuals from growth accounting. The country's respectable TFP growth with an annual average of 2 percent or more in the 1980s fell to virtual stagnation in the 1990s. The findings also show that Japan's productivity growth rate in the 1990s is not only historically low but also lags considerably behind the contemporaneous growth rates in other OECD nations.

From the perspective of growth theory, a fall in TFP leads to a reduction in the steady-state returns on capital and a slowdown of economic growth. Therefore, the neoclassical growth framework suggests that it was the fall in TFP that was largely behind the great recession that lasted in Japan for a decade, even though any developments in the demand side observed during the 1990s may have been relevant for the country's business cycles.

The Japanese experience bears important lessons for the countries that have tried hard to stop the economic slump following the global financial crisis from developing into a long-running recession. Any amount of government efforts targeted at the demand side is likely to fail to carry their economies to a sustainable path of growth unless they are accompanied by a meaningful improvement in TFP. Subsequently, the fiscal stimulus packages full of "shovel-ready" projects may prop up the economy just for a short period, but would never be effective measures for preempting possible "double-dips" or "triple-dips".

Against the backdrop of ever-widening recent sovereign debt crisis, it is time to completely overhaul the fiscal stimulus packages that have been hastily assembled in many parts of the world since the start of financial crisis. In both developed and developing nations, the governments need to design its spending more wisely with a high priority given to structural transformation that will improve the economy's TFP.

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