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Julen ESTEBAN-PRETEL

the University of Tokyo

SAWADA Yasuyuki

RIETI



Research Institute of Economy, Trade & Industry, IAA

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On the Role of Policy Interventions in Structural Change and Economic Development: The Case of Postwar Japan*

Julen Esteban-Pretel [†]
University of Tokyo

Yasuyuki Sawada [‡]
University of Tokyo

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Abstract

In this paper, we study the structural change occurring in Japan's post-World War II era of rapid economic growth. We use a two-sector neoclassical growth model with government policies to analyze the evolution of the Japanese economy in this period and to assess the role of such policies. Our model is able to replicate the empirical behavior of the main macroeconomic variables. Three findings emerge from our policy analysis. First, neither price and investment subsidies to the agricultural sector, nor industrial policy play a crucial role in the rapid postwar growth. Second, while a government subsidy for families in urban areas could have facilitated migration from the agricultural to the non-agricultural sector, such a policy would not have improved the overall performance of the Japanese economy. Finally, had there existed a labor migration barrier, the negative long-run level effect on output would have been substantial.

Keywords: Two-sector growth model; Structural change; Government policies

JEL Classification: E1, O1, O41

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[†]Corresponding author: Faculty of Economics, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan. E-mail: julen@e.u-tokyo.ac.jp; Tel: +81-3-5841-5526; Fax: +81-3-5841-8294.

[‡]Faculty of Economics, University of Tokyo. Email: sawada@e.u-tokyo.ac.jp

1 Introduction

Japan's successful postwar development has been a popular topic of investigation in a wide range of economic literature. On the empirical side, economic historians such as Ohkawa and Rosovsky (1973) have made a significant contribution in constructing and analyzing long-term macroeconomic data from Japan following Simon Kuznets' quantitative approach to the modern economic growth. In the tradition of development economics, researchers such as Minami (1968) and Yasuba (1975) employed the dualistic development models of Lewis (1954), Jorgenson (1961), and Ranis and Fei (1961), to identify the timing of Japan's turning point from a labor-abundant economy to the labor-shortage phase. More policy-oriented studies, such as James, Naya, and Meier (1989) and World Bank (1993) can be found in the context of Japan and other high-performing East Asian economies including South Korea and Taiwan.

Many theoretical studies from the 1960s and 1970s formulated multi-sector economic growth models, beginning with Shinkai (1960), Uzawa (1961, 1963), and Inada (1963). Indeed, Inada and Uzawa (1972) and Inada, Sekiguchi, and Shoda (1993) present a formal theory of economic development to explain the mechanism of an aggregate industrial development pattern in Japan, which takes into account the important role of food and labor supply as well as the performance of the subsistence sector.

While such theoretical works generate important findings, there is a lack of studies trying to reproduce the Japanese structural change and development experience in the post-World War II period using modern modeling techniques and carefully choosing the basic structural parameters of the model to match actual data. Moreover, there is almost no formal quantitative study which can be used to rigorously evaluate the effectiveness of actual policy interventions on the structural change in Japan. This is a serious omission in the literature because, for example, the importance of targeted industrial policies has been debated repeatedly in the context of Japanese economic development (Johnson, 1982; Krugman, 1987; Komiya, Okuno and Suzumura, eds., 1988; Lee, 1993; Beason and Weinstein, 1996; Miwa and Ramsayer, 2004). However, without counterfactual information, it is difficult to evaluate such policies properly. An exception is Hayashi and Prescott (2008), who employ a two-sector neoclassical growth model to investigate the reasons why the Japanese miracle did not take place until after World War II.

Following the model developed by Hayashi and Prescott (2008) and extending their analysis using postwar Japanese data, the objective of this study is to further fill the gap in the existing literature by building a two-sector general equilibrium growth model for Japan's postwar era. By doing so, we seek to understand the forces underlying the rapid economic growth and structural change in employment from agricultural to non-agricultural activities. We further use the model to formally evaluate the effectiveness of postwar Japan's unique policy interventions.

The model is a two-sector neoclassical growth model, where the driving forces of the economy are innovations in technology, in the form of increases in total factor productivity (TFP), in both agricultural and non-agricultural sectors. We assume Engel's law, which implies a lower need for

workers in the agricultural sector as productivity grows and a shift towards manufacturing and other non-agricultural industries. We incorporate several government policies aimed at protecting agriculture while helping the development of both sectors. Such policies include price subsidies for agricultural goods and subsidies for the rental cost of capital for farmers and firms. The model is carefully calibrated to match the Japanese empirical evidence in the postwar period, and then solved using a perfect foresight shooting algorithm as in Hayashi and Prescott (2002).

Since the relative price of agricultural goods is determined endogenously in the model and there are a variety of government policies in place, pure agricultural productivity growth may not be sufficient to explain the rapid structural transformation in Japan, as indicated by Hayami Akino, Shintani and Yamada (1975) and Minami (1994).¹ Our results show, however, that it is the combination of TFP growth in the agricultural sector together with very high TFP growth in the non-agricultural industries that is responsible for the structural transformation and the Japanese economic miracle. We also show that the government policies studied in this paper do not play a crucial role, and that other than changing the relative prices, they do not affect the overall behavior of aggregate macroeconomic variables such as output per capita or the capital-output ratio.

Our model and solution method, while based on Hayashi and Prescott (2008), is also related to the analytical framework of two-sector growth models such as Matsuyama (1992, 2007), Banerjee and Newman (1998) and Eswaran and Kotwal (1993); it is also related to the numerical techniques of two-sector growth models of Casselli and Coleman (2001), Laitner (2000), Hansen and Prescott (2002), and Lucas (2004); it likewise relates to the recent development accounting literature, such as Vollrath (2008), Gollin, Parente and Rogerson (2004, 2007), Restuccia, Yang and Zhu (2008), and Temple (2005).

The remainder of this paper is organized as follows. In the next section, we briefly describe the postwar Japanese economy by looking at several time series macroeconomic variables. Section 3 explains the two-sector growth model and its equilibrium conditions which will be matched with data. In Section 4, we briefly present the data and calibration procedure. Section 5 shows the simulation results and a set of counterfactual policy experiments. In the final section, we conclude and discuss the direction of future research.

2 Postwar Japanese Economy

In order to understand the Japanese experience in the postwar era and be able to build a model that can study the policies used by government, we now summarize the main stylized facts of the Japanese economy in the period between the end of World War II and the start of the

¹Solow (2005) criticized the two-sector growth models, which are constructed for a consumer-good-producing sector and an investment-good-sector for farm and non-farm sectors in the development context, stating that too much in those models turned out to depend on differences in factor intensity between the sectors, and that we have very little in the way of facts or intuition about that issue. We overcome this criticism by carefully matching the postwar Japanese data with the model .

Lost Decade, i.e., 1990. We also summarize some of the most important and discussed policies implemented by the government during this time. These policies are later included in the model to understand their impact on the structural change and overall evolution of the economy.

2.1 Stylized Facts

With the aid of Figures 1 and 2, we first show the main stylized facts of the postwar Japanese economy, which the model presented below tries to reproduce. The description of the data and its sources can be found in the Data Appendix.

1. Rapid Output Growth

Figure 1 (a) shows the well-known fact that Japan's economic recovery after the war was followed by a rapid output increase in the 1950's and 1960's. This rapid growth process of the Japanese economy, which has been studied widely in the existing literature such as Ohkawa and Rosovsky (1973), Minami (1994), Nakamura (1995), and Kosai and Kaminski (1986), continued until 1973, the year of global inflation and the first oil crisis. The average growth rate of GNP between 1956 to 1973 was a remarkable 7.4%. The oil crisis terminated Japan's rapid growth era, which was followed by a period of slower but stable growth, with an average per capita output growth of 2.8% between 1973 and 1990.

2. Decrease in Agricultural Employment Share

Figure 1 (b) presents the share of employment in agriculture. As we can see, as Japan's rapid growth progressed, labor flowed from the agricultural sector into non-agricultural industries. Such a trend clearly started in the 1950s, when the share of employment in agriculture was close to 34%, and continued until the first oil crisis, when it was 12%. After the first oil shock, labor continued to shift towards the non-agricultural industries, but at a lower rate, stabilizing at around 6% in 1990.

3. Increase in the Capital-Labor Ratio in Agriculture Relative to Non-Agriculture

The massive labor migration prior to the first oil crisis coincided with an increase in the capital-labor ratio of agriculture relative to non-agriculture, as can be seen in Figure 1 (c). This pattern seems to arise from a sharp increase in capital inputs in agriculture after the war. In fact, a distinct feature of the postwar agricultural development of Japan was the spurt of farm mechanization through "mini-tractORIZATION," i.e., a rapid introduction of small-scale tractors with less than 10 horsepower (Hayami, et al., 1975). This mechanization was paralleled by the period of industrial and economic development since the mid-1950s.

4. Low Agricultural Wages

Figure 1 (d) shows the existence of a persistent differential between wages in the agricultural and non-agricultural sectors. In spite of this large wage gap, the adjustment of the economy

through migration out of agriculture did not occur rapidly, but continued for more than 15 years. At first sight, it seems puzzling why labor market adjustment did not take place in a shorter period of time. Indeed, this slow adjustment may be a reflection of a unique feature of Japanese farm households. After the war, farmers found it increasingly difficult to finance household expenses by farming alone, and were forced to supplement their income with earnings outside of agriculture. As industrialization gradually spread throughout the country, farmers' sons and daughters started working in the industrial sector. In this way, it became common for agricultural households to combine farm earnings and non-farm income. Accordingly, Japan experienced a growing shift from full-time to part-time farming households since the 1950's. In fact, in Japan a significant portion of farmers are officially classified as part-time farm households of the second type, i.e., farm households with more than half of their total income coming from non-farm sources.² In particular, Hayami and Godo (2002, 2005) report that in the postwar period, for households with some agricultural income, on average only one quarter of their income came from agricultural activities. As a result, the gap between agriculture and non-agriculture, in terms of income per household, was reduced substantially, and even disappeared after the 1970s, as shown in Table 8-7 of Hayami and Godo (2002) and Table 7-10 of Hayami (1986).

5. TFP Increase in Agriculture and Non-Agriculture

Figures 2 (a) and (b) show the evolution of TFP in the agriculture and non-agriculture sectors, respectively. Both TFP series increased significantly until the first oil crisis, although the growth rate of non-agricultural TFP was higher than that of agriculture. It has been argued that TFP growth in agriculture resulted as a consequence of the accumulation and diffusion of the potential in agricultural technology. In other words, this TFP improvement was the consequence of the implementation of many of the technological advancements that had been accumulated during the prewar period (Hayami and Ruttan, 1985). In non-agricultural industries, TFP augmentation became possible through the adoption, imitation, and assimilation of the flows of technical know-how from advanced nations. Some theories state that the absorptive capacity with which the gap between the technology frontier and the current level of productivity is filled should closely depend on the level of human capital (Benhabib and Spiegel, 2005). Ohkawa and Kohama (1989) discuss how Japan is a typical example of borrowed technology-driven industrialization, whose success is attributable to its rapid human capital accumulation through which the absorptive capacity of foreign technology has been enabled. Improvements in non-agricultural TFP in Figure 2 (b) can be understood as a realization process of the potential of imported technologies.

²While the proportion of farm households of total households in Japan declined by 40 % between 1960 and 1995, part-time households of the second type increased by more than 20 % (Hayami and Godo, 2002).

2.2 Policy Interventions

It has been argued in the literature that the Japanese government implemented a variety of policies, both in the agricultural and non-agricultural sectors, to try to stimulate the growth and development of the economy (Ohkawa and Rosovsky, 1973; Komiya, Okuno and Suzumura, 1988; Kosai and Kaminski, 1986; Minami, 1994; Nakamura, 1995; and Hayami and Godo, 2002). We describe here some of the most important policies.³

In the agricultural sector, there were two major policy instruments. The first was price subsidies for agricultural goods producers. The second, investment subsidies for the mechanization of the agricultural sector. The main policies for non-agricultural industries related to promoting industrial development through investment and loan subsidies. Let us explain these policies in more detail.

The agriculture pricing policy applied mostly to rice and other major crops. The price of rice was under the direct control of the Food Agency (Shokuryo Cho). Under this policy, the government purchased rice from rice producers at a predetermined procurement price and later sold it to consumers at a lower price. Since the rice price was remarkably stable, and the gap between rice procurement and sales prices was about five percent between 1957 and 1960, the deficit of the Food Control Special Account (Shokkan Kaikei) did not rise prior to that year. Yet, in 1960, due to strong political pressure from farmers' organizations, the procurement rice price formula was modified to reflect and cover the cost of production at the paddy field. With this new formula, the price paid to producers rose rapidly and the government rice purchase price became significantly higher than the government sales price. The price gap rose to 25.55% on average between 1962-1980. Due to this price gap, the deficit of the Food Control Special Account became one of the most serious sources of overall government budget deficits.

The second agriculture policy was the provision of production investment subsidies. There were two major forms of such subsidies, one by supplying direct investment transfers and the other by providing production loans at subsidized interest rates. Hayami and Godo (2002) estimated that about half of total farm investments were financed by government subsidies after 1970. The ratio of the amount of the investment subsidies to total agricultural investment was 26% in 1960, 45% in 1970, 58% in 1980 and 1990 (Hayami and Godo, 2002).

In the non-agricultural sector, during the period of rapid economic growth, the government promoted industrial development with various instruments within the framework of overall industrial policy. Particularly, it has been often argued that provisions of subsidized interest rate for targeted industries through the Fiscal Investment and Loan Program (FILP or Zaisei Tou Yushu in Japanese) facilitated investments (Ogura and Yoshino, 1988; Cargill and Yoshino, 2003). FILP is organized and managed by the government using the surplus funds of the postal savings

³While we believe that we cover major policy interventions in our study, there were other policies employed by the government during this period. In this study, we focus on those incorporated in the model whose effect we can quantify and study. Hence, effects generated by other policies should be captured by productivity changes in our model.

and social security funds. Through FILP, these surplus funds were employed to finance investments in infrastructure-related public enterprises such as the National Railways and the Nippon Telegraph and Telephone Corporation and private-sector investments through public financial institutions, such as the Housing Loan Corporation, Japan Development Bank, Export-Import Bank, and the Small Business Finance Corporation (Ogura and Yoshino, 1988). The targeted industries through this low interest rate policy included a wide variety of industries such as sea transport, electric power, shipbuilding, automobiles, machinery, iron and steel, coal mining, and petroleum refining (Ogura and Yoshino, 1988).

During the period studied and up to the present, the government also implemented various taxation policies such as taxing labor income and the corporate sector. While distortionary taxation is one of the determinants of economic decision-making, we do not dwell on the details because they are fairly standard and were not identified as major development-related policies during the era of rapid growth in Japan.

3 The Two-Sector Growth Model

The model we employ to account for the facts presented above is a neoclassical growth model, in the style of Cass-Koopmans, with two sectors, agriculture and non-agriculture. Time is discrete and there are three types of infinitely lived agents in the economy: Households, firms, and the government. Let us study them in turn.

3.1 Household

There is a representative household in the economy, and in every period the household decides how much to consume and how much to save. It also decides how much labor and capital to supply to each sector. The supply of labor is in terms of persons and not hours, since hours, while entering the production function, are assumed to be exogenous to the household and firms in the model.

We make the assumption that the household is composed of smaller groups, which we call families, although these families have no decision power since all decisions are made at the household level. There are two locations in the model, the rural area, where the agricultural and some of the non-agricultural sector's firms are located, and the urban area, where most of the non-agricultural firms operate. Following the evidence presented in Hayami and Godo (2002, 2005), we assume that each rural family is composed of five members, and each urban family of 4 members. Furthermore, in order to be consistent with their evidence concerning the earnings of families in Japan, we assume that when a family lives in the rural area, two members work in the agricultural sector and the other three work for non-agricultural firms. All members in the urban area work in the non-agricultural sector.

We further assume that in order to work in the urban area, workers must incur a cost, Φ_t . This

cost proxies for expenditures such as housing rent, commuting, and outside food consumption. In Japan, most farmers own their own land and house and self-produce an important fraction of their food consumption, which is why we assume that this cost is zero for families members living in the rural area.⁴

The household earns income from labor by its members and from renting capital to firms. The government taxes part of that income in two ways. It taxes the labor income of the non-agricultural workers⁵ at rate τ_{lt} , and the return on non-agricultural capital at rate τ_{kt} .

The problem of the representative household is to choose $\{c_{at}, c_{nt}, K_{t+1}, s_{et}, s_{kt}\}_{t=0}^{\infty}$ to maximize

$$\sum_{t=0}^{\infty} \beta^t N_t u(c_{at}, c_{nt}) \quad (1)$$

$$\begin{aligned} \text{s.t. } & q_t C_{at} + C_{nt} + T_t + K_{t+1} = \Pi_t + w_{at} h_{at} s_{et} E_t + (1 - \tau_{lt}) w_{nt} h_{nt} (1 - s_{et}) E_t \\ & - \Phi_t \left((1 - s_{et}) E_t - \frac{3}{2} s_{et} E_t \right) + (1 - \delta_t) K_t + r_{at} s_{kt} K_t \\ & + r_{nt} (1 - s_{kt}) K_t - \tau_{kt} (r_{nt} - \delta_t) (1 - s_{kt}) K_t, \end{aligned} \quad (2)$$

where $\beta \in (0, 1)$ is the discount factor; N_t is the working-age population in the economy; $c_{at} = C_{at}/N_t$ and $c_{nt} = C_{nt}/N_t$ are the consumption per capita of the agricultural and non-agricultural goods; q_t is the relative price of the agricultural good; Π_t is the return on land, which is one of the factors of production in the agricultural sector; K_t is the aggregate stock of capital, which depreciates at a rate δ_t , and is supplied to agricultural and non-agricultural firms, with shares s_{kt} and $(1 - s_{kt})$ respectively; s_{et} is the share of employment supplied to the agricultural sector, where E_t is total employment, which is taken as given by the household; hours of work in each sector are respectively, h_{at} and h_{nt} ; w_{at} , w_{nt} , r_{at} and r_{nt} are the pre-tax wages per hour, and the return on capital for each sector; the term $\Phi_t \left((1 - s_{et}) E_t - \frac{3}{2} s_{et} E_t \right)$ represents the expenditures associated with the non-agricultural workers who live in an urban area⁶; T_t is the total amount of lump-sum taxes levied by the government; we assume Engel's Law and impose the Stone-Geary utility function $u(c_a, c_n) \equiv \mu_a \log(c_a - \bar{a}) + \mu_n \log c_n$, where μ_a , μ_n and \bar{a} are non-negative parameters.

There should be no arbitrage possibilities in the labor and capital markets, which means that the household chooses the fraction of employment and capital for each sector so that the after-tax

⁴According to the Housing and Land Survey conducted by the Statistics Bureau of the Ministry of Internal Affairs and Communications, house and land ownership rates of households engaged in agriculture, forestry, and fishery were 96.3% and 96.7%, respectively, in 2003 <<http://www.stat.go.jp/data/jyutaku/2003/pdf/15-7.pdf>>. The corresponding rates for employees in the private sector were 57.8% and 54.7%, respectively.

⁵It has been argued that in Japan a very high fraction of farmers evade taxes.

⁶Each rural family is composed of 5 members, and 3 of those members work in the non-agricultural sector. Hence, since $s_{et} E_t$ individuals work in the agricultural sector, and for every 2 members of a rural family who work in the agricultural sector, there are 3 who work in the other sector, then $\frac{3}{2} s_{et} E_t$ persons work in the non-agricultural sector and do not pay the cost.

return is equated. In the case of employment, what needs to be equalized is the income of the family in a rural area and in an urban area. The equalization of income between the two types of families is consistent with the evidence presented by Hayami and Godo (2005), and which is explained in the previous section. In terms of the model, when the household decides to assign a worker to the agricultural sector, it also assigns three workers to non-agricultural sector in the rural area, where they do not pay the cost Φ_t . However, every member of the urban area pays the cost Φ_t . Hence, the appropriate comparison is not between wages in the two sectors, but between the income of a whole family in the rural area and a whole family in the urban area. Assuming that the cost per worker of living in an urban area is proportional to the non-agricultural wage, $\Phi_t = \phi_t w_{nt} h_{nt}$, s_{et} is chosen so that the following condition holds

$$2w_{at}h_{at} + 3(1 - \tau_{lt}) w_{nt}h_{nt} = 4(1 - \tau_{lt} - \phi_t) w_{nt}h_{nt}. \quad (3)$$

For capital, s_{kt} is chosen so that in equilibrium the following condition is satisfied

$$r_{at} = (1 - \tau_{kt})r_{nt} + \tau_{kt}\delta_t, \quad (4)$$

and we define r_t as this after-tax rate, i.e., $r_t = r_{at} = (1 - \tau_{kt})r_{nt} + \tau_{kt}\delta_t$.

The savings and consumption decision for the household delivers the following optimal conditions

$$\frac{\partial u(c_{at}, c_{nt})}{\partial c_{at}} = \frac{q_t}{\lambda_t}, \quad (5)$$

$$\frac{\partial u(c_{at}, c_{nt})}{\partial c_{nt}} = \frac{1}{\lambda_t}, \quad (6)$$

$$\lambda_{t+1} = \beta\lambda_t[1 + r_{t+1} - \delta_t], \quad (7)$$

where $1/\lambda_t$ is the Lagrange multiplier associated with the household's budget constraint. Given the Stone-Geary utility function presented above, equations (5) and (6) deliver the following two Frisch demand equations

$$c_a(q_t, \lambda_t) = \mu_a \frac{\lambda_t}{q_t} + \bar{a}, \quad (8)$$

$$c_n(\lambda_t) = \mu_n \lambda_t. \quad (9)$$

3.2 Firms

Firms rent capital and labor from the household and produce output which is sold back to the consumers. In order to stimulate the use of capital, the government provides a subsidy for the rental cost of capital, where the subsidy rates are π_{kat} and π_{knt} for agricultural and non-agricultural sectors respectively. The government further protects the interests of the agricultural sector by providing a subsidy on the price of their goods. The consumer pays a price q_t for the

agricultural good, but the price received by the producer is $(1 + \pi_{qt}) q_t$.

3.2.1 Firm in the Agricultural Sector

A firm in the agricultural sector rents capital and hires labor to maximize its profits.⁷ Therefore, every period the firm chooses $\{K_{at}, L_{at}\}$ to maximize

$$(1 + \pi_{qt})q_t Y_{at} - (1 - \pi_{kat})r_{at}K_{at} - w_{at}L_{at}, \quad (10)$$

$$s.t. \quad Y_{at} = A_{at}K_{at}^{\alpha_a}L_{at}^{\eta}, \quad (11)$$

where Y_{at} is agricultural output; A_{at} is total factor productivity (TFP) in this sector; L_{at} is labor input of the firm, which is a combination of hours and employees; and $\alpha_a, \eta \in (0, 1)$, with $\alpha_a + \eta < 1$.

The optimal conditions for this problem deliver the equilibrium factor prices

$$r_{at} = \frac{(1 + \pi_{qt})}{(1 - \pi_{kat})} \alpha_a q_t A_{at} K_{at}^{\alpha_a - 1} L_{at}^{\eta}, \quad (12)$$

$$w_{at} = \eta(1 + \pi_{qt})q_t A_{at} K_{at}^{\alpha_a} L_{at}^{\eta - 1}. \quad (13)$$

3.2.2 Firm in the Non-Agricultural Sector

Similarly, a firm in the non-agricultural sector chooses $\{K_{nt}, L_{nt}\}$ to maximize

$$Y_{nt} - (1 - \pi_{knt})r_{nt}K_{nt} - w_{nt}L_{nt} \quad (14)$$

$$s.t. \quad Y_{nt} = A_{nt}K_{nt}^{\alpha_n}L_{nt}^{1 - \alpha_n}, \quad (15)$$

where Y_{nt} , A_{nt} , and L_{nt} are respectively, output, TFP, and labor input in the non-agricultural sector; $\alpha_n \in (0, 1)$.

The factor prices for this sector are found through the optimal conditions of the previous problem

$$r_{nt} = \frac{1}{(1 - \pi_{knt})} \alpha_n A_{nt} K_{nt}^{\alpha_n - 1} L_{nt}^{1 - \alpha_n}, \quad (16)$$

$$w_{nt} = (1 - \alpha_n) A_{nt} K_{nt}^{\alpha_n} L_{nt}^{-\alpha_n}. \quad (17)$$

3.3 Government

The government collects lump-sum labor and capital income taxes from the household, subsidizes the price of agricultural goods and the rental cost of capital for firms, and spends G_t units of non-agricultural output as government expenditures. The government budget constraint, which

⁷The production function of the agricultural firms also includes land as a factor, but since it is assumed to be fixed, it is not explicitly shown in the problem.

is assumed to be balanced every period, is as follows

$$\begin{aligned} T_t + \tau_{lt} w_{nt} h_{nt} (1 - s_{et}) E_t + \tau_{kt} (r_{nt} - \delta_t) (1 - s_{kt}) K_t \\ = \pi_{qt} q_t Y_{at} + \pi_{kat} r_{at} K_{at} + \pi_{knt} r_{nt} K_{nt} + G_t. \end{aligned} \quad (18)$$

3.4 Equilibrium

A competitive equilibrium, given K_0 , and a government policy $\{G_t, T_t, \tau_{lt}, \tau_{kt}, \pi_{qt}, \pi_{kat}, \pi_{knt}\}_{t=0}^{\infty}$, is a set of allocations for the household $\{c_{at}, c_{nt}, K_{t+1}, s_{et}, s_{kt}\}_{t=0}^{\infty}$ and for the firms $\{Y_{at}, Y_{nt}, K_{at}, K_{nt}, L_{at}, L_{nt}\}_{t=0}^{\infty}$, and a price system $\{q_t, w_{at}, w_{nt}, r_{at}, r_{nt}\}_{t=0}^{\infty}$, such that agents optimize, markets clear, and government has a balanced budget. Agents optimize on two sides: first, given government policy and prices, the allocations solve the household's maximization problem, whose solution is characterized by equations (3) to (7). Second, given government policy and prices, the allocations solve the profit maximization of firms in each sector, whose solution is characterized by equations (12), (13), (16) and (17). Markets clear in four markets: agricultural good, non-agricultural good, capital, and two labor markets, respectively,

$$Y_{at} = N_t c_{at}, \quad (19)$$

$$Y_{nt} - G_t = N_t c_{nt} + \left((1 - s_{et}) E_t - \frac{3}{2} s_{et} E_t \right) \phi_t w_{nt} h_{nt} + K_{t+1} - (1 - \delta) K_t, \quad (20)$$

$$K_t = K_{at} + K_{nt}, \quad (21)$$

$$L_{at} = h_{at} s_{et} E_t, \quad (22)$$

$$L_{nt} = h_{nt} (1 - s_{et}) E_t. \quad (23)$$

Finally, government has a balanced budget, as in equation (18).

3.5 Reduced Detrended Equilibrium

The equilibrium stated above is non-stationary since TFP in both sectors and population grow over time. We now define two trends, detrend the model, and reduce it to a dynamic system of two equations.

Following Hayashi and Prescott (2008), we define $X_{Qt} \equiv A_{at}^{-1} (h_{at} E_t)^{-\eta} A_{nt}^{\frac{1-\alpha_a}{1-\alpha_n}} (h_{nt} E_t)^{1-\alpha_a}$ and $X_{Yt} \equiv A_{nt}^{\frac{1}{1-\alpha_n}} \frac{h_{nt} E_t}{N_t}$. X_{Qt} is the trend of the relative price of agricultural goods, q_t ; X_{Yt} is the trend of the non-agricultural sector per-capita variables, and that of λ_t ; and $\frac{X_{Yt}}{X_{Qt}}$ is the trend of the agricultural sector per-capita variables. Hence we can define the following detrended variables

$$\tilde{k}_t \equiv \frac{K_t}{X_{Yt} N_t}, \quad \tilde{y}_{nt} \equiv \frac{Y_{nt}}{X_{Yt} N_t}, \quad \tilde{c}_{nt} \equiv \frac{C_{nt}}{X_{Yt} N_t}, \quad \tilde{q}_t \equiv \frac{q_t}{X_{Qt}}, \quad \tilde{\lambda}_t \equiv \frac{\lambda_t}{X_{Yt}},$$

where

$$\tilde{y}_{nt} = \tilde{k}_t^{\alpha_n} (1 - s_{kt})^{\alpha_n} (1 - s_{et})^{1 - \alpha_n}.$$

Similarly we can define

$$\tilde{q}_t \tilde{y}_{at} \equiv \frac{q_t Y_{at}}{\frac{X_{Yt}}{X_{Qt}} N_t}, \quad \tilde{q}_t \tilde{c}_{at} \equiv \frac{q_t C_{at}}{\frac{X_{Yt}}{X_{Qt}} N_t},$$

where

$$\tilde{y}_{at} = \tilde{k}_t^{\alpha_a} s_{kt}^{\alpha_a} s_{et}^{\eta}.$$

Using these definitions in the equilibrium conditions and plugging the factor prices into the Euler equation (7) and into the non-agricultural market clearing condition (20), we can reduce the equilibrium into a system of two equations in \tilde{k}_t and $\tilde{\lambda}_t$:

$$\left(1 - \psi_t - \phi_t (1 - \alpha_n) \frac{1 - \frac{5}{2} s_{et}}{1 - s_{et}}\right) \tilde{y}_{nt} = \frac{c_n (\tilde{\lambda}_t X_{Yt})}{X_{Yt}} + \frac{N_{t+1} X_{Yt+1} \tilde{k}_{t+1}}{N_t X_{Yt}} - (1 - \delta) \tilde{k}_t, \quad (24)$$

$$\frac{X_{Yt+1} \tilde{\lambda}_{t+1}}{X_{Yt}} = \beta \tilde{\lambda}_t \left\{ 1 + \frac{1 - \tau_{kt+1}}{(1 - \pi_{knt+1})} \frac{\alpha_n \tilde{y}_{nt+1}}{(1 - s_{kt+1}) \tilde{k}_{t+1}} - (1 - \tau_{kt+1}) \delta_t \right\}, \quad (25)$$

where $\psi_t \equiv \frac{G_t}{Y_{nt}}$.

The other variables of the model can be found using the equilibrium conditions once we have solved for \tilde{k}_t and $\tilde{\lambda}_t$. In particular, we solve for $(s_{kt}, s_{et}, \tilde{q}_t)$ given $(\tilde{k}_t, \tilde{\lambda}_t, X_{Yt}, X_{Qt})$ through the following three equations

$$\tilde{q}_t \tilde{y}_{at} = \frac{\tilde{q}_t c_a (\tilde{q}_t X_{Qt}, \tilde{\lambda}_t X_{Yt})}{\left(\frac{X_{Yt}}{X_{Qt}}\right)}, \quad (26)$$

$$\frac{1 - \tau_{kt}}{1 - \pi_{knt}} \frac{\alpha_n \tilde{y}_{nt}}{(1 - s_{kt}) \tilde{k}_t} + \tau_{kt} \delta_t = \frac{1 + \pi_{qt}}{1 - \pi_{kat}} \frac{\alpha_a \tilde{q}_t \tilde{y}_{at}}{s_{kt} \tilde{k}_t}, \quad (27)$$

$$(1 - \tau_{lt} - 4\phi_t) (1 - \alpha_n) \frac{\tilde{y}_{nt}}{(1 - s_{et})} = 2\eta (1 + \pi_{qt}) \frac{\tilde{q}_t \tilde{y}_{at}}{s_{et}}. \quad (28)$$

4 Calibration and Simulation Procedure

To simulate the model, we need to provide values for the parameters of the model and for the exogenous variables. The complete description of the data can be found in the Data Appendix. The next subsections explain the calibration and describe the exogenous variables used in the simulations.

4.1 Calibration

We use Japanese data for the period between 1956 to 1990 to calibrate the model parameters. The period in the model is one year.

The discount factor, β , is chosen to match the following aggregate values: the capital-output ratio of the economy in the final period of the simulation, 1990, is set at 1.87; steady state growth rate is assumed to be 2%; non-agricultural capital tax rate τ_{kt} is set at 0.35 based on Mendoza, Razin, and Tesar (1994); and non-agricultural capital-output ratio is 1.87 from Hayashi and Prescott (2003). The resultant discount factor is that $\beta = 0.963$.

The per period utility function is of the Stone-Geary type and has the form $u(c_a, c_n) \equiv \mu_a \log(c_a - \bar{a}) + \mu_n \log c_n$, where \bar{a} is the agricultural good subsistence level. We follow Gollin, Parente and Rogerson (2004) and calibrate the value of \bar{a} to match the share of agricultural output in 1956, 12%, and set it to $\bar{a} = 63.2$. Combining the two Frisch demand equations (8) and (9), we can obtain the following relationship between μ_a , μ_n and \bar{a} :

$$\frac{\mu_a}{\mu_n} = \frac{(c_{at} - \bar{a})q_t}{c_{nt}}. \quad (29)$$

We normalize $\mu_a + \mu_n = 1$ and given \bar{a} we choose μ_a to satisfy (29) for the average between 1956 and 1990, and set it to $\mu_a = 0.0012$.

The parameters in the technology function of the two sectors are chosen as follows. First we set $\alpha_n = 0.33$, as in Hayashi and Prescott (2008). Then we calibrate α_a so that the no-arbitrage condition on capital (4) is satisfied over the sample period, and set it to $\alpha_a = 0.36$. Finally, with data from Hayami et al. (1975), we calibrate and set η to $\eta = 0.45$ using the following condition from Hayashi and Prescott (2008):

$$\eta = (1 - \alpha_a) \times \frac{\text{labor share}}{\text{labor share} + \text{land share}}.$$

Table 1 summarizes the choice of parameter values.

Table 1: Model Parameters

$\beta = 0.963$	$\mu_a = 0.0025$	$\bar{a} = 63.2$
$\alpha_n = 0.33$	$\alpha_a = 0.36$	$\eta = 0.45$

4.2 Exogenous Variables

The variables that are exogenous in the model, whose paths we feed in order to solve the model, are: TFP in both sectors, A_{at} and A_{nt} ; Population, N_t ; aggregate employment, E_t ; hours in each sector, h_{at} , h_{nt} ; capital depreciation rate, δ_t ; government expenditure share of output, ψ_t ; labor and capital income tax rate, τ_{lt} , τ_{kt} ; agricultural price subsidy rate, π_{qt} ; firm's capital rental cost in both sectors, π_{kat} and π_{knt} ; and the fraction of wages devoted to pay cost of living in urban area, ϕ_t .

The sources and construction of these variables for the sample from 1956 to 1990 can be found in the Data Appendix. After the final year of the simulation, 1990, we assume that these variables remain constant at the 1990 level,⁸ as is done in other studies that use the perfect foresight shooting algorithm solution technique (i.e. Hayashi and Prescott, 2002 and 2008, Chen Imrohoroglu and Imrohoroglu, 2007).

4.3 Simulation Procedure

In order to numerically solve the model, we follow Hayashi and Prescott (2002, 2008) and impose that the economy reaches a steady state far enough in the future. Then, starting from the conditions of the Japanese economy in 1956, we use a perfect foresight shooting algorithm to find the path of the variables in the model from this initial condition to the final steady state. This path is conditional on the evolution of the exogenous variables which are fed to the model and which were stated above.⁹

5 Results

As explained in Section (2) the Japanese postwar structural change experience was characterized by a high output growth period, accompanied by a decrease in the share of employment in agriculture and an increase in the capital-labor ratio of the agricultural sector relative to that of the non-agricultural industries. Other facts about this period related to variables in the model, and against which we test our theory, are the decline in the share of capital in agriculture, the increase in the overall capital-output ratio, and the relatively slow movement of the relative price of agricultural goods, with a fairly constant mean, over the whole sample period.

We now proceed to explain the performance of the model in terms of the previous facts. Later we present the effects of the counterfactual experiments performed to understand the role of the different government policies in the postwar structural change.

5.1 Simulation Results

As we can see from Figures 3 (a)-(f), our model can predict the actual time series data of the postwar Japanese economy reasonably well. In particular, the model is able to reproduce the evolution of the main macroeconomic variables as well as the variables of our focus, such as per capita GNP, capital output ratio, and employment share. Specifically, as can be seen in Figure 3 (a), the model captures well the rapid decline in the share of agricultural employment

⁸This assumption may seem extreme, since Japan entered a long recession in 1991 and it has been argued that at least TFP declined sharply for almost a decade (Hayashi and Prescott, 2002). However, the focus of the paper is on the long-run structural change and development of the Japanese economy, which by the year 1990 was clearly finalized. Moreover, recent data suggests that the Japanese economy and in particular TFP are growing again at a healthy rate. Hence since we do not aim to explain the Japanese Lost Decade, we abstract from this period and stop our simulation in 1990, assuming constant values for the exogenous variables after that year.

⁹For more details on the simulation procedure, see Appendix A of Hayashi and Prescott (2008).

in the period prior to the first oil shock, followed by a slower decline after this event. As shown in Figure 3 (e), the model also reproduces the high output growth from 1956 to 1973 and its slowdown thereafter, although it slightly over-predicts the growth rate in the first part of the sample. The movements of the capital-output ratio (Figure 3 (d)), which in the data is fairly stable until 1970, then increases over the 1970s and stabilizes again with the arrival of the 1980s, are also captured by our model, although the level is slightly higher than in the data.

For the other model variables of interest, such as the share of capital in agriculture shown in Figure 3 (b), the relative capital per worker across industries in Figure 3 (c) and the relative price of the agricultural good in Figure 3 (f), the model's prediction is less accurate. Possibly, these discrepancies arise from short-run volatilities of the agricultural TFP as shown in Figure 2. However, the model is able to reproduce the overall downward or upward trends of these variables, and to capture the changes in their levels from the mid-1950s to the end of the bubble period.

5.2 Effects of the Government Policies

We now show the results of the counterfactual experiments, in which we change the values of the government policy instruments, leaving everything else the same, in order to study how crucial the different policies are in accounting for the evolution of the Japanese economy in this period.

The first counter-factual policy simulation involves setting all the government subsidies to agricultural and non-agricultural sectors to zero, i.e. $\pi_{qt} = 0$, $\pi_{kat} = 0$, and $\pi_{knt} = 0$. As we can see in Figures 4 (a)-(f), the removal of these policies does not generate significant changes in the behavior of most of the variables. However, we can observe that the agricultural employment share becomes slightly higher, both in the transition and in the long-run, than in the benchmark simulation. We can also see that the relative price of agricultural products is substantially higher throughout the period, which seems to be a direct consequence of the removal of price subsidies and the cost increase in the capital utilization. These results indicate that, overall, subsidies affect the agricultural sector in a small measure, mostly by keeping prices low, but the aggregate impact is not necessarily large. We also perform policy simulations by sequentially setting each one of these subsidies to zero. However, we find that the overall impact of such policy changes is not significantly different from the results shown in Figure 4 (a)-(f).¹⁰ The results of this counterfactual policy experiment may be seen as surprising, since they seem to contradict many existing studies which point to the existence of serious inefficiencies in the Japanese economy generated by agricultural protection policies (Hayami and Godo, 2002) and the significance of industrial policies during the rapid growth era (Johnson, 1982; Kosai and Kaminski, 1986). As for the industrial policy, some researchers have argued that the mode in which the government intervened in Japan was through dialogue, persuasion, and signaling, since government-directed credits through FILP were less than ten percent of total loans made to the industrial sector

¹⁰These results are available from the authors upon request.

(Hayami and Godo, 2005). Komiya, Okuno, and Suzumura, eds., (1988) also conclude that the contributions of industrial policies in Japan came from the sharing of information between the government and the private sector through dialogues in various committees and councils. In fact, a more accurate interpretation of our results is that if policies affected postwar rapid growth, they should have operated through TFP. The results of our paper are consistent with these views on Japan's industrial policy.

The second policy change we study is the inclusion of a government subsidy to help families in the urban areas with the cost associated with living there,¹¹ Φ_t in the model. In particular we perform a counterfactual experiment where the government covers a fraction of this cost, and set this fraction to be 30%. The results show an important decline in the share of agricultural employment, especially in the transition, although not in the long-run; there is no significant change in the behavior of output or the capital-output ratio. In other words, while these costs are an important part of keeping workers in the agricultural sector, they do not improve the overall impressive performance of Japan in terms of output. The irrelevance of this subsidy in terms of changing the evolution of output can be understood by looking at the behavior of the share of capital in agriculture. Parallel to the lower employment share relative to the benchmark model, this subsidy produces an increase in the share of capital. This result hinges on two assumptions of the model. The first is Engel's law, which implies that there a certain amount of agricultural goods which need to be produced. The second is the free mobility of capital across sectors. With the inclusion of this subsidy, the household finds it optimal to assign less workers to the agricultural sector and produces the necessary food with more capital. Hence, for the non-agricultural output, which dominates GNP both in the data and in our model, there is an increase in labor input, but a decrease in capital, which leaves output and the capital-output ratio mostly unaffected.

Finally, we incorporate the key assumption that Hayashi and Prescott (2008) use to explain the delay in the Japanese miracle, namely the existence of a labor barrier that prevented workers from migrating out of agriculture. This barrier imposes a minimum number of workers in this sector of 14 million. Introducing this mobility friction in our model results in a dramatic change in some of the variables. In particular, as would be expected, the share of labor in agriculture is much higher and decreases very slowly. However, as in the case of the subsidy to the cost of living in an urban area, this different evolution of the employment share is mirrored by a decrease in the share of capital in agriculture. In this case, since workers are not allowed to move out of agriculture, but the economy only needs a certain amount of food production, capital is shifted out of agriculture and into non-agricultural industries. In this case, however, the change in the evolution of output is significant. With substantially less workers in the non-agricultural sector, output grows fast, but less than in the benchmark case because decreasing marginal productivity of capital affects output considerably. This growth difference accumulates over time and becomes

¹¹While we are not aware that the Japanese government actively pursued this policy, we perform this counterfactual experiment to understand the effects of a policy of this type in the evolution of the economy.

significant by the end of the sample. The difference between the output from the data and in this counterfactual experiment is nearly 18 % for 1990. Therefore, our results may be seen as being consistent with those derived by Hayashi and Prescott (2008). With the barrier, Japan's postwar GNP growth would have been lower and the long-run level effect substantial. In other words, the elimination of this barrier can be seen as one of the important contributors to Japan's postwar economic miracle.

5.3 Robustness

In order to assess the robustness of our results, we perform four additional analyses.¹² First, we consider a small open economy version of our model. While existing studies such as Ohkawa and Rosovsky (1973) and Minami (1994), as well as the canonical openness index based on the Penn World Table data, show that modeling Japan as a closed economy is a good approximation, assuming a closed or an open economy model is crucial to the results of papers such as Matsuyama (1992). Hence, we relax the closed economy assumption by postulating that both agriculture and non-agriculture goods are tradable, but capital is not¹³. In the small open economy specification of the model, where consumption goods are tradable in the international market, the relative price of the agriculture good, q_t , becomes exogenous. The simulation results for the model under the small open economy specification indicate that the main qualitative conclusions of the paper still hold. That is, the Japanese growth miracle and the decline in agricultural employment share are due to the high growth of TFP, and the effect of government policies are not substantial.

Second, we assess the importance of TFP growth in the agricultural sector by removing it from the simulation. That is, we assume that only non-agricultural TFP grows over the studied period, whereas agricultural TFP remains at the 1956 level. Under this alternative path of sectoral TFP, the model generates very similar results as the baseline model, suggesting that the the most important factor is the high TFP growth in the non-agricultural sector.

Third, in order to assess the role of the divergence path of TFP between the two sectors in the structural change, we perform two simulations in which we impose the same growth rate of TFP for both sectors. When we set the growth rate to be that of non-agricultural TFP, the qualitative results do not fundamentally change. However, in the simulation where we set TFP in non-agriculture to grow at the same rate as the observed growth rate in agricultural TFP, output per capita grows at a much lower rate than the baseline model. Hence, this corroborates our prior statement that it is the high growth of non-agricultural TFP which drives the Japanese miracle and the structural change of the economy.

Finally, we assess the performance of the model when we remove from it the assumption of the family structure and the costs of living in the urban area. Given the large differences in the data in terms of wages for agricultural and non-agricultural activities, we cannot assume that

¹²These results are not shown in this paper, but are available from the authors upon request.

¹³The flow of capital goods is highly restricted in Japan for our sample period, especially in the first part. Hence, modeling capital as a non-tradable good is a reasonable assumption.

the household freely assigns workers to each sector, since that would imply wage equalization in the model and contradict the data. Therefore, the simple exercise we perform is to remove the family assumption, and consider the share of agricultural employment as exogenous. This is still an interesting exercise, since under this specification, the model still delivers endogenously important macroeconomic variables, such as aggregate capital, the share of capital in agriculture, aggregate output, and the relative price of agricultural goods. The simulation results show that the main conclusions of the paper are still valid.

6 Conclusions

In this paper, we extend the two-sector neoclassical growth model of Hayashi and Prescott (2008) to include policies used by the Japanese government in the post-World War II period, and study the structural change in Japan's rapid post-war economic growth. Our model is able to reproduce the actual time series data for the postwar Japanese economy reasonably well. Based on our model, three findings emerge from the policy simulations. First, price and investment subsidies for the agricultural sector and industrial policy in the form of the Fiscal Investment and Loan Program (FILP) have limited impact on the aggregate growth performance of Japan. Second, while a government subsidy to help families in urban areas could have facilitated migration from the agricultural to the non-agricultural sector in the rapid growth era, such a policy would not have improved Japan's overall performance. Finally, with the counterfactual labor migration barrier, Japan's postwar GNP growth would have been lower and the long-run level effect would have been substantial. In other words, the elimination of the barrier can be seen as one of the most important contributors to Japan's postwar economic miracle.

There are, however, two caveats to our study. First, while we believe that our policy simulations cover the major policy interventions in postwar Japan, there are other important interventions, including other forms of industrial policy, i.e. special capital depreciation schemes (Ogura and Yoshino, 1988), public investments in a variety of infrastructures, and agricultural trade protection policies, which we do not consider explicitly in our model. A correct interpretation of our results is that if policies affected postwar rapid growth, they should have operated through TFP in our model. Second, we impose the assumption of exogenous TFP. While this exogeneity assumption delivers a close fit of our model to the data, it can be relaxed by endogenizing human capital investment in international technological transfers (Benhabib and Spiegel, 2005), considering firms' research and development decisions (Romer, 1990), or incorporating government's agricultural research and extension (R&E) activities (Rustichini and Schmitz, 1991). We leave the inclusion of these dimensions for future work (Aoki, et al., 2009).

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Data Appendix

In this appendix, we describe the sources and construction of the data employed in the analysis. Basically, we employ and extend the data set of Hayashi and Prescott (2008),¹⁴ which compiled postwar data series for real GNP, its deflator, the size of the working-age population, employment in agricultural and non-agricultural sectors, hours worked per week in the two sectors, and nominal private capital stock. The extensions we make to their data and the other variables are explained below.

- K_{at} (agricultural capital stock): We extrapolate postwar agriculture capital stock data by the following procedure. From 1956 to 1962, we extrapolate the data using agricultural real net capital stock in Long Term Economic Statistics (LTES) of Hitotsubashi University. Specifically, we use their “net capital stock in agriculture in million yen, 1934-36 prices” in LTES, Vol.3, Table 3. From 1963 to 1970, we extrapolate the data using agricultural real gross capital stock in Ohkawa and Shinohara (1979) (“gross capital stock in agriculture in million yen, 1934-36 prices” in Ohkawa and Shinohara, 1979, Table A18). As for the data after 1971, we extrapolate the series using agricultural real net capital stock in the database called JIP2008, which is extracted from RIETI’s web page <<http://www.rieti.go.jp/en/database/JIP2008/index.html>>. This real net capital stock in JIP2008 is the sum of “rice, wheat production,” “miscellaneous crop farming,” “live-stock and sericulture farming,” and “agricultural services” (in million yen, 2000 prices) in JIP2008.
- A_{at} and A_{nt} (agricultural and non-agricultural TFP): We use the the production functions on both sectors (11) and (15), and data on output, capital, employment and hours in each sector to calculate the TFP as the Solow residual:

$$A_{at} = \frac{Y_{at}}{K_{at}^{\alpha_a} (E_{at}h_{at})^\eta}, \quad A_{nt} = \frac{Y_{nt}}{K_{nt}^{\alpha_n} (E_{nt}h_{nt})^{1-\alpha_n}}.$$

- δ (depreciation rate of capita): Data on the depreciation rate of capital is taken from the Hayashi and Prescott (2002) database, which is downloadable from Fumio Hayashi’s web page <http://fhayashi.fc2web.com/Hayashi-Prescott1_data.htm>.
- C_{at} and C_{nt} (consumption of agriculture and non-agriculture goods): Nominal aggregate consumption is also taken from the Hayashi and Prescott (2002) database. Since from the model, $p_{at}C_{at} = p_{at}Y_{at}$, where $C_{at} \equiv N_t C_{at}$, nominal non-agricultural consumption can be calculated by $PC_t - p_{at}C_{at}$ where PC_t is nominal aggregate consumption.
- ψ_t (ratio between government consumption and non-agricultural value added): Nominal government consumption is taken from the Hayashi and Prescott (2002) database. We

¹⁴The dataset used for the 2006 working paper version of their paper can be found in Fumio Hayashi’s website <<http://fhayashi.fc2web.com/Hayashi-Prescott2.htm>>.

divide this government consumption, G_t , by nominal non-agricultural value added, Y_{nt} , to derive the ratio, ψ_t .

- τ_{kt} (tax rate on capital income) and τ_{lt} (tax rate on labor income): Tax rates on capital and labor incomes are taken from Mendoza, Razin, and Tesar (1994) and its further update are extracted from Enrique Mendoza's web page <<http://www.econ.umd.edu/~mendoza/pp/newtaxdata.pdf>>
- π_{qt} (subsidy rate on agricultural output price): The subsidy rate on output price in the agricultural sector is based on the gap between the government's procurement and the sales prices of rice. This price gap is further adjusted for transaction costs that are estimated by the absolute price gap in years 1988 to 2000. Then the adjusted price gap is multiplied by the proportion of rice controlled by the government. The government procurement prices are taken from Statistics on Rice Price (Beika Ni Kansuru Shiryo) of the Food Agency (Shokuryo Cho) for the years 1951 to 1992. The sales price is from the Statistics on Rice Price (Beika Ni Kansuru Shiryo) of the Food Agency for the years 1966 to 1992. Data on the shares of government-controlled rice are from the statistical appendix of a White Paper on Agriculture (Shokuryo Nogyo Nouson Hakusyo Sanko Tokei Hyo) for 1960 to 1995.
- π_{kat} (subsidy rate on agricultural capital investments): The subsidy rate on capital investment in the agricultural sector is derived by dividing the total amount of capital subsidies by a product of the return on capital and capital stock of the agricultural sector. For the total amount of capital subsidies, we employ direct capital subsidy transfers in the agricultural sector extracted from the Social Accounting of Agriculture and Farmers (Nougyou Oyobi Nouka No Shakai Kanjyou), Ministry of Agriculture, Forestry, and Fishery, for the fiscal years Showa 37 (1962), Showa 50 (1975), Showa 55 (1980), Showa 60 (1985), Heisei 2 (1990), and Heisei 7 (1995).
- π_{knt} (subsidy rate on non-agricultural capital investments): We employ the interest rate subsidy rate through the Fiscal Investment and Loan Program (FILP) to proxy for the interest rate subsidy rate in the non-agricultural sector. Time series data on the subsidy rate is taken from Figure 4.10 of Cargill and Yoshino (2003). As pages 114 and 115 of Cargill and Yoshino (2003) explain, their subsidy rate is defined as the total amount of interest rate subsidy divided by after-tax retained earnings, i.e., after-tax income less dividends. We multiply this rate by after-tax retained earnings (Rieki Jouyo Kin) data for all firms in all industries, which is taken from Financial Statements Statistics of Corporations by Industries (Hojin Kigyo Toukei) of Ministry of Finance <<http://www.mof.go.jp/1c002.htm>>. Since this value represents $\pi_{knt}r_{nt}K_{nt}$, we divide it by $r_{nt}K_{nt}$, so that we obtain π_{knt} . We decide to employ total industry data because the after-tax retained earnings levels of agricultural industry are negligible.
- ϕ_t (fraction of wages devoted to living cost in urban area): ϕ_t is obtained from the equal-

ization of incomes for families in rural and urban areas, equation (3)

$$2w_{at}h_{at} + 3(1 - \tau_t)w_{nt}h_{nt} = 4(1 - \tau_t - \phi_t)w_{nt}h_{nt},$$

which implies

$$\phi_t = \frac{1}{4} \left(1 - \tau_t - 2 \frac{w_{at}h_{at}}{w_{nt}h_{nt}} \right).$$

Figure 1: Japan's Postwar Experience



Notes: Wages in panel (d) are calculated to be consistent with the definition of wages in the model. Therefore, they are calculated using data on output, capital and labor input, as the marginal product of labor: $w_{at} = \eta q_t A_{at} K_{at}^{\alpha_a} L_{at}^{\eta-1}$, and $w_{nt} = (1 - \alpha_n) A_{nt} K_{nt}^{\alpha_n} L_{nt}^{-\alpha_n}$. Actual wages in the data show a similar pattern, except the ratio of w_{at}/w_{nt} fluctuates around 30%.

Figure 2: Evolution of Total Factor Productivity (1956=100)

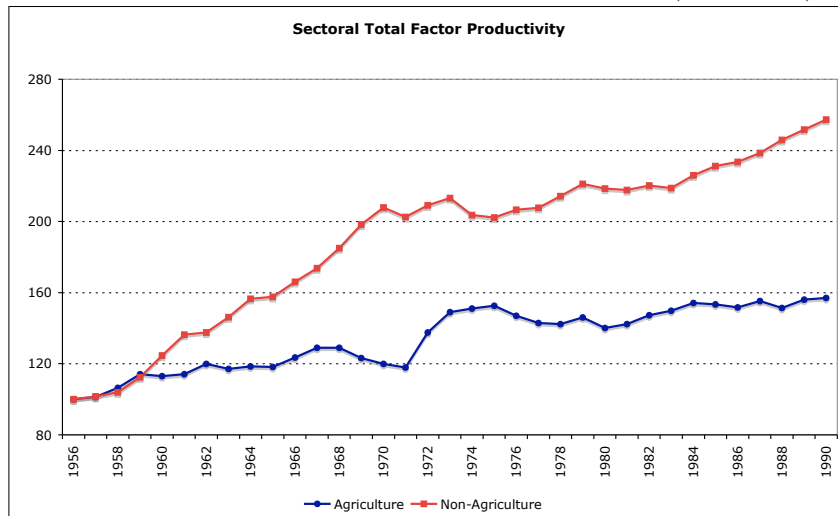


Figure 3: Benchmark Model Simulation Results

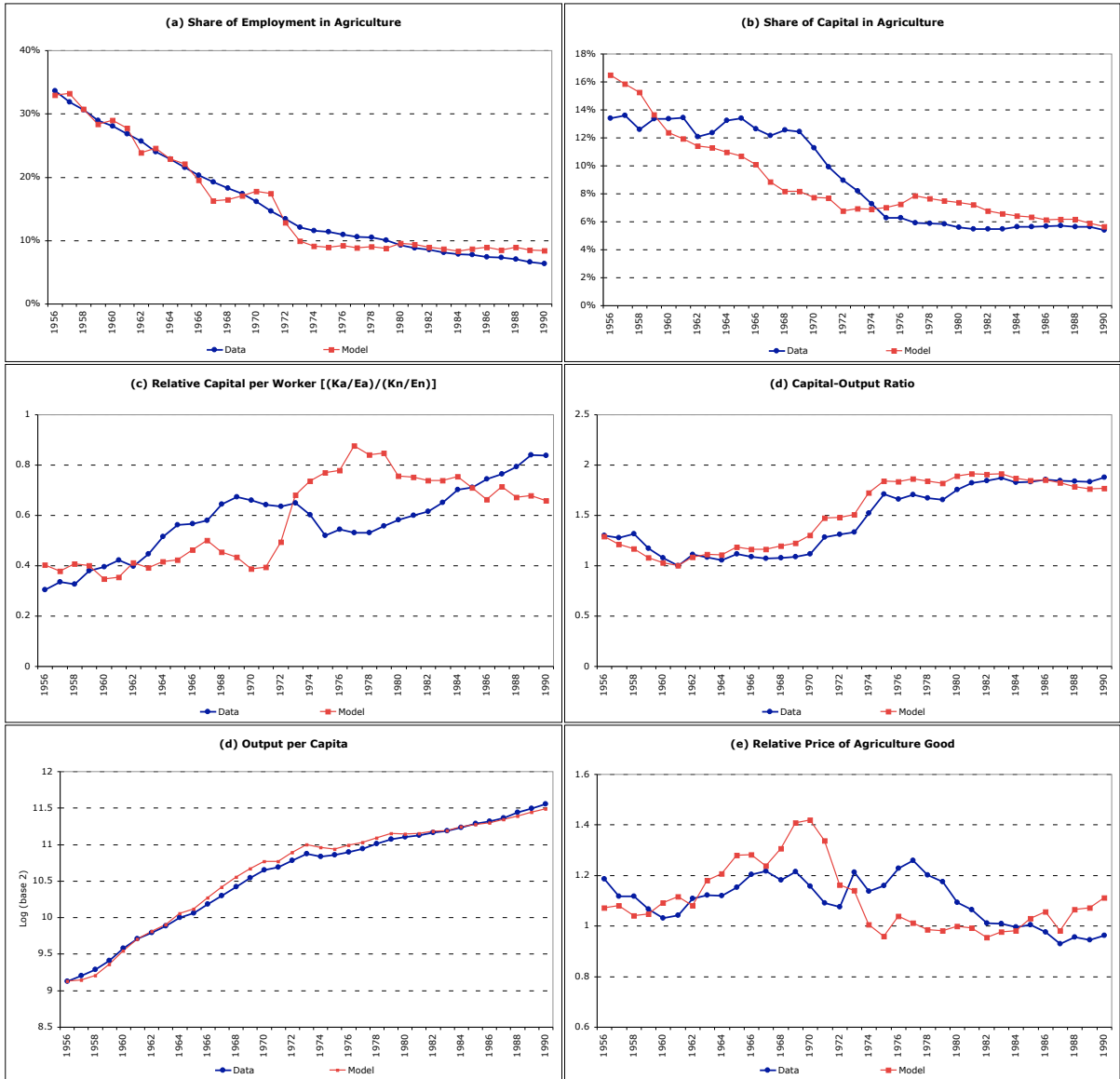


Figure 4: Policy Counter-Factual Simulation Results

