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Abstract

Using a simple framework, I reexamine the Hayashi and Prescott hypothesis (2006) that a barrier to labor mobility that maintained high agricultural employment was a cause of the stagnation in the prewar Japanese economy. I find that the labor misallocation between the agricultural and non-agricultural sectors had larger negative effects on the prewar Japanese aggregate productivity than on the postwar aggregate productivity. However, this is not because the wage differential between the sectors was larger but because the agricultural nominal share was larger in prewar Japan. Finally, I show that a model that does not assume a barrier to labor mobility can explain the change in the prewar and postwar agricultural employment rate and nominal share. These results suggest that factors other than labor misallocation are responsible for the stagnation in the prewar Japanese economy.

Keywords: agriculture; barrier to labor mobility; prewar Japan; resource misallocation; two-sector model
JEL classifications: E1, N3, N5, O1, O4

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1 Introduction

In contrast with the post-World War II prosperity, the prewar Japanese economy was relatively stagnant in terms of per capita GNP and aggregate productivity. Hayashi and Prescott (2006) (hereafter HP) propose a hypothesis that this stagnation was caused by a barrier to labor mobility between the agricultural and non-agricultural sectors; further, they argue that it disappeared after Japan lost the war and was occupied by the Allied Powers. They consider the high agricultural employment in prewar Japan as evidence of the barrier, and develop a model to evaluate the effect of the barrier on the prewar Japanese GNP and aggregate productivity.

This paper reexamines whether high labor immobility was a cause of the stagnation in the prewar Japanese economy. For this purpose, I first develop a simple accounting framework that measures the effect of labor misallocation on aggregate productivity.[1] I find that the magnitude of the measured misallocation effect on aggregate productivity is larger in prewar period than in the postwar period, which confirms with HP's hypothesis.

Next, using this framework, I decompose the change in the prewar and postwar misallocation effects into the effect by the change in the wage differential between sectors and the effect of the change in the sectoral nominal share. I find that all the changes in the measured misallocation effect arise from the effect by the change in the sectoral nominal share and that the degree of wage differential is similar before and after the war. This result is in sharp contrast to the literature on misallocation, where differences in prices (output and factor prices) are the causes of misallocation.[2]

However, even if the wage differential between sectors has remained unchanged, it does not necessarily imply that the barrier to labor mobility did not exist. In addition, the motivation of HP is to explain the relatively high agricultural employment rate in prewar. Therefore, I examine whether a model that does not assume a barrier to labor mobility can explain the change in the prewar and postwar sectoral nominal share and the change in the agricultural employment rate. I find that a model of structural transformation, developed by Laitner (2000), Gollin, Parente and Rogerson (2002), Gollin, Parente and Rogerson (2007), and Duarte and Restuccia (2007), among others, can help answer these questions. The results of my investigation suggest that a barrier to labor mobility might not have been an important factor for the stagnation of the prewar Japanese economy, and that other factors are

[1]By focusing on the effect of labor misallocation on aggregate productivity, I can examine the misallocation effect in an analytically simple way.

[2]See e.g., Restuccia and Rogerson (2007), Restuccia, Yang and Zhu (2008), Hsieh and Klenow (2007), and Alfaro, Charlton and Kanczuk (2007) among others.

responsible for the prewar Japanese stagnation.

The remainder of the paper is organized as follows. Section 2 presents a two-sector model. Using this model, Sections 3 and 4 explain how to measure the effect of labor misallocation on aggregate productivity and how to decompose the misallocation effect into several factors. Using the framework developed in the above sections, Section 5 measures the misallocation effect and conducts the decomposition. Finally, Section 6 develops a model that does not assume a barrier to labor mobility, and shows that this model can explain the change in the prewar and postwar agricultural employment rates and nominal share.

2 Two-Sector Model

There are two sectors in the economy–agricultural and non-agricultural. The production function for each sector is

$$Y_i = A_i K_i^{\theta_i} L_i^{\eta_i}, \quad i \in \{a, n\}, \tag{1}$$

where Y_i, A_i K_i, and L_i are sectoral output, productivity, capital, and labor, respectively, and the subscripts a and n denote agricultural and non-agricultural sectors, respectively. The production functions are the same as those in HP. Capital and labor inputs are homogeneous between sectors.

As in HP, the wage rate in each sector can be different due to the barrier to labor mobility, but otherwise, firms are competitive. Then, the first-order conditions (FOCs) are

$$r = \frac{\theta_i p_i Y_i}{K_i}, \tag{2}$$

$$w_i = \frac{\eta_i p_i Y_i}{L_i}, \tag{3}$$

where p_i is the output price and r and w_i are the factor prices of capital and labor, respectively.

Finally, the resource constraints are given as follows:

$$\begin{aligned} K &= K_a + K_n, \\ L &= L_a + L_n, \end{aligned}$$

where K and L are the aggregate capital and labor supply, respectively.

Under this setting, the allocation of capital and labor in each sector can be written as follows (for the derivation, see Appendix A):

$$K_i = \frac{\sigma_i \theta_i}{\theta} K, \tag{4}$$

$$L_i = \frac{\sigma_i \eta_i}{\eta} \widehat{\lambda}_{Li} L, \tag{5}$$

where σ_i is sectoral nominal share $p_i Y_i / (\sum_j p_j Y_j)$, $\theta \equiv \sum_i \sigma_i \theta_i$, $\eta \equiv \sum_i \sigma_i \eta_i$, and

$$\widehat{\lambda}_{Li} \equiv \frac{\frac{1}{w_i}}{\sum_j \frac{\sigma_j \eta_j}{\eta} \frac{1}{w_j}} = \frac{1}{\sum_j \frac{\sigma_j \eta_j}{\eta} \frac{w_i}{w_j}}.$$

From the last equation, we find that $\widehat{\lambda}_{Li}$ is a function of the sectoral nominal shares and wage ratios. Suppose that there is no barrier to labor mobility. Then, $w_a = w_n$. In this case, $\widehat{\lambda}_{Li}$ becomes equal to unity. On the other hand, if there is a barrier, $\widehat{\lambda}_{Li}$ is not equal to unity, and thus, the labor allocation deviates from the no barrier case. Empirically, $\widehat{\lambda}_{Li}$ is derived from (5).

3 Misallocation Effect on Aggregate Productivity

This section analyzes how a barrier to labor mobility affects the prewar Japanese aggregate productivity. For this purpose, I first compare the output of the actual economy with a barrier, Y^{b}, with that of a fictitious economy without a barrier, Y^{nb}. (The superscripts "b" and "nb" denote barrier and no barrier economies, respectively.) In the no barrier economy, $w_a^{\mathrm{nb}} = w_n^{\mathrm{nb}}$ (thus, $\widehat{\lambda}_{Li}^{\mathrm{nb}} = 1$) and that the productivity of each sector is the same in the two economies.[3] The Tornqvist index of the output difference between the economies is defined as follows:

$$\sum_i \bar{\sigma}_i \ln \left(\frac{Y_i^{\mathrm{b}}}{Y_i^{\mathrm{nb}}} \right),$$

where $\bar{\sigma}_i \equiv (\sigma_i^{\mathrm{b}} + \sigma_i^{\mathrm{nb}})/2$. The reason I use the Tornqvist index is its tractability.[4] Diewert (1978) shows that the Tornqvist index is numerically very close

[3]This assumption is slightly different from HP's. They assume that in the no barrier economy, $w_a^{\mathrm{nb}} h_a = w_n^{\mathrm{nb}} h_n$, where h_i is the number of hours worked and is exogenously given. For simplicity, I assume $w_a^{\mathrm{nb}} = w_n^{\mathrm{nb}}$. If my assumption is the same as that of HP, the effect of labor misallocation on aggregate productivity generally decreases.

[4]This index also has a microfoundation. See Appendix B.

to the Fisher index (which is used in HP). By substituting (1), (4), and (5) in this definition, I obtain

$$\sum_i \bar{\sigma}_i \ln\left(\frac{Y_i^{\mathrm{b}}}{Y_i^{\mathrm{nb}}}\right) \simeq \sum_i \bar{\sigma}_i \eta_i \ln \widehat{\lambda}_{Li}^{\mathrm{b}} + \bar{\theta} \ln\left(\frac{K^{\mathrm{b}}}{K^{\mathrm{nb}}}\right) + \bar{\eta} \ln\left(\frac{L^{\mathrm{b}}}{L^{\mathrm{nb}}}\right), \tag{6}$$

where $\bar{\theta} \equiv \sum_i \bar{\sigma}_i \theta_i$, and $\bar{\eta} \equiv \sum_i \bar{\sigma}_i \eta_i$.[5]

I define the difference in aggregate productivity as follows:

$$\ln\left(\frac{A^{\mathrm{b}}}{A^{\mathrm{nb}}}\right) \equiv \sum_i \bar{\sigma}_i \ln\left(\frac{Y_i^{\mathrm{b}}}{Y_i^{\mathrm{nb}}}\right) - \bar{\theta} \ln\left(\frac{K^{\mathrm{b}}}{K^{\mathrm{nb}}}\right) - \bar{\eta} \ln\left(\frac{L^{\mathrm{b}}}{L^{\mathrm{nb}}}\right).$$

This is the standard definition of the difference in aggregate productivity.

By rewriting (6), using the definition of aggregate productivity, I obtain

$$\ln\left(\frac{A^{\mathrm{b}}}{A^{\mathrm{nb}}}\right) \simeq \sum_i \bar{\sigma}_i \eta_i \ln \widehat{\lambda}_{Li}^{\mathrm{b}}. \tag{7}$$

The RHS captures the effect of labor misallocation on aggregate productivity. Note that if $w_a^{\mathrm{b}} = w_n^{\mathrm{b}}$, then the RHS becomes zero. I refer to the RHS as the (baseline) misallocation effect.

4 Decomposition of the Misallocation Effect

Even if the wage differential between the agricultural and non-agricultural sectors in prewar Japan is as large as that in postwar Japan, the prewar misallocation effect can be large because the sectoral nominal share, σ_i, also affects the misallocation effect. In order to identify the sectoral nominal share effect, I also calculate the misallocation effect of prewar Japan, where the wage differential between sectors changes to the average wage differential of the postwar periods but sectoral nominal shares are calculated from the prewar data. I refer to this as the counterfactual misallocation effect. The counterfactual misallocation effect can be calculated as follows:

$$\sum_i \bar{\sigma}_i^{\mathrm{pre}} \eta_i \ln \widehat{\lambda}_{Li}^{\mathrm{pre}}\left(\frac{w_i^{\mathrm{post}}}{w_j^{\mathrm{post}}}\right), \tag{8}$$

where

$$\widehat{\lambda}_{Li}^{\mathrm{pre}}\left(\frac{w_i^{\mathrm{post}}}{w_j^{\mathrm{post}}}\right) \equiv \frac{1}{\sum_j \frac{\sigma_j^{\mathrm{pre}} \eta_j}{\eta^{\mathrm{pre}}} \frac{w_i^{\mathrm{post}}}{w_j^{\mathrm{post}}}}.$$

[5] Other terms are approximately zero. For details, see Appendix C.

(The superscripts pre and post denote prewar and postwar Japan, respectively.) Empirically, the postwar average of the ratio of wage rate, $w_i^{\text{post}}/w_j^{\text{post}}$, is measured using a firm's FOC (3).

Using the counterfactual misallocation effect, the difference in prewar and postwar baseline misallocation effect is decomposed as follows:

$$\sum_i \bar{\sigma}_i^{\text{pre}} \eta_i \ln \widehat{\lambda}_{Li}^{\text{pre}} - \sum_i \bar{\sigma}_i^{\text{post}} \eta_i \ln \widehat{\lambda}_{Li}^{\text{post}} = \underbrace{\sum_i \bar{\sigma}_i^{\text{pre}} \eta_i \ln \widehat{\lambda}_{Li}^{\text{pre}} - \sum_i \bar{\sigma}_i^{\text{pre}} \eta_i \ln \widehat{\lambda}_{Li}^{\text{pre}}(\frac{w_i^{\text{post}}}{w_j^{\text{post}}})}_{\text{Wage differential term}}$$
$$+ \underbrace{\sum_i \bar{\sigma}_i^{\text{pre}} \eta_i \ln \widehat{\lambda}_{Li}^{\text{pre}}(\frac{w_i^{\text{post}}}{w_j^{\text{post}}}) - \sum_i \bar{\sigma}_i^{\text{post}} \eta_i \ln \widehat{\lambda}_{Li}^{\text{post}}}_{\text{Sectoral nominal share term}}. \tag{9}$$

If the difference in the baseline misallocation effects between the prewar and postwar Japan is due to the change in wage differential, the wage differential term accounts for most of the difference. On the other hand, if the difference in the sectoral nominal share is the cause of the difference in baseline misallocation effects, the sectoral nominal share term accounts for most of the difference.

5 Measurement

This section measures the prewar (1885-1940) and postwar (1960-1973) averages of the baseline and counterfactual misallocation effects, using (7) and (8), and conducts decomposition, using (9).

I use the dataset provided by HP. As in HP, for labor input L_i, I use hours worked times employment in their data. For the sectoral nominal share, I use the value added share in their data. In order to calculate the misallocation effects, I have to assume the sectoral nominal share under no barrier condition. I assume that the sectoral nominal share under the no barrier condition is the same as that under the barrier condition (referred to as case 1). As a robustness check, I also calculate the baseline and counterfactual misallocation effects, using the simulation result of the sectoral nominal share under the no barrier condition in HP (referred to as case 2). Case 2 is provided only for the prewar averages since their simulation result is available only in prewar period. Finally, following HP, I specify the labor share parameter of the agricultural sector, η_a, as 0.638, and that of the non-agricultural sector, η_n, as 2/3.[6]

[6]These values are the labor shares of value added in their paper.

Table 1 reports the results. The magnitude of the prewar baseline misallocation effect is larger than that of the postwar baseline misallocation effect, which is consistent with HP. On the other hand, the magnitude of the counterfactual misallocation effect is also large. Table 2 reports the decomposition. Obviously, the sectoral nominal share term occupies the entire difference in the prewar and postwar misallocation effects. The reason for this is that the wage differential between sectors is rather broad in the postwar period: the prewar average of the wage ratio between sectors w_a/w_n is 0.33, while the postwar average is 0.31.

6 Prediction of Sectoral Shares Using a No Barrier Model

Even if the wage differential between sectors is the same before and after the war, it does not necessarily imply that a barrier to labor mobility does not exist. In addition, the motivation of HP is to explain the relatively high agricultural employment rate in prewar Japan. Therefore, this section demonstrates that a model of structural transformation can explain the change in prewar and postwar sectoral employment rate and the nominal share without assuming a barrier to labor mobility.[7]

In the model, households only care to consume the subsistence amount of agricultural goods $\bar{a}$. Then, the following equation holds:

$$\bar{a} = \frac{Y_a}{N} = \frac{Y_a}{N_a}\frac{N_a}{N},$$

where N_a and N denote the agricultural and total employment.[8] As in Duarte and Restuccia (2007), I assume that the agricultural labor productivity Y_a/N_a is exogenously given.[9] Then, given $\bar{a}$, from the above equation, I can obtain the model prediction of agricultural employment share N_a/N.

Figure 1 plots the data and model prediction of the agricultural employment rate (I assume 0.08 for $\bar{a}$). The model fits the postwar data and the prewar data after 1910 fairly well. In addition, I can also derive the model prediction of the sectoral nominal share.[10] The model prediction of the sectoral nominal share also fits the data after 1910 well, when the wage

[7] This section draws on Nakamura (2008), who compares the postwar Japanese data on sectoral employment rate with the prediction of Duarte and Restuccia's (2007) model.

[8] Here, I simply assume that the total employment is equal to the total population.

[9] This assumption might be problematic. Endogenizing the capital accumulation has been left for future research.

[10] Using (3), I can obtain the model prediction of the agricultural nominal share as

differential between sectors is assumed to be constant over time and equal to the postwar average (see Figure 2).[11]

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follows:

$$\sigma_a = \frac{w_a L_a/\eta_a}{w_a L_a/\eta_a + w_n L_n/\eta_n} = \frac{1}{1 + \frac{\eta_a}{\eta_n}\frac{w_n h_n}{w_a h_a}\left(\frac{N}{N_a} - 1\right)},$$

where h_i denotes the number of hours worked.

[11]Precisely speaking, unlike the previous sections, the wage differential here is not the wage differential per hour but the differential per worker.

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Appendix

A Derivation of (4) and (5)

(5) can be derived as follows:

$$\begin{aligned} L_i &= \frac{\frac{w_i L_i}{w_i}}{\sum_j \frac{w_j L_j}{w_j}} L \\ &= \frac{p_i Y_i \eta_i \frac{1}{w_i}}{\sum_j p_j Y_j \eta_j \frac{1}{w_j}} L \\ &= \frac{\sigma_i \eta_i \frac{1}{w_i}}{\sum_j \sigma_j \eta_j \frac{1}{w_j}} L \\ &= \frac{\sigma_i \eta_i}{\eta} \widehat{\lambda}_{Li} L. \end{aligned}$$

(4) can be derived in the same way.

B A Microfoundation of the Tornqvist Index

Suppose the aggregator function $Y = Y(Y_a, Y_n)$ (it can be interpreted as the utility function or the aggregate production function). I assume that the aggregator function is constant returns to scale and that $\frac{\partial Y}{\partial Y_i} = p_i$ (then,

$Y = p_a Y_a + p_n Y_n$). By applying the mean value theorem, I obtain

$$\ln\left(\frac{Y(Y_a^{\mathrm{b}}, Y_n^{\mathrm{b}})}{Y(Y_a^{\mathrm{nb}}, Y_n^{\mathrm{nb}})}\right) = \sum_i \frac{\partial \ln Y}{\partial \ln Y_i} \ln\left(\frac{Y_i^{\mathrm{b}}}{Y_i^{\mathrm{nb}}}\right)$$
$$= \sum_i \sigma_i \ln\left(\frac{Y_i^{\mathrm{b}}}{Y_i^{\mathrm{nb}}}\right).$$

The last equation is approximately equal to the Tornqvist index.

C Derivation of (6)

In order to derive (6), we need to show that terms $\bar{\theta}\sum_i \frac{\bar{\sigma}_i\theta_i}{\bar{\theta}}\Delta\ln\left(\frac{\sigma_i\theta_i}{\theta}\right)$ and $\bar{\eta}\sum_i \frac{\bar{\sigma}_i\eta_i}{\bar{\eta}}\Delta\ln\left(\frac{\sigma_i\eta_i}{\eta}\right)$ are approximately zero (Δ denotes the difference). These terms are approximately zero, because when $\sum_i \gamma_i = 1$, the following relation holds:

$$\sum_i \gamma_i \Delta \ln \gamma_i \simeq \sum_i \gamma_i \frac{\Delta\gamma_i}{\gamma_i}$$
$$= 1 - 1$$
$$= 0.$$

	Baseline			Counterfactual
	Prewar	Postwar	Difference	Prewar
Case 1	-9.43%	-3.84%	-5.58%	-9.69%
Case 2	-6.39%			-6.97%

Table 1: Baseline and counterfactual misallocation effects. Notes: The values under the prewar correspond to the 1885-1940 average and the values under the postwar correspond to the 1960-1973 average. The difference implies the difference in the prewar and postwar misallocation effects. Case 1 denotes the case where the sectoral nominal share under the no barrier condition is the same as that under barrier. Case 2 denotes the case where the sectoral nominal share is borrowed from the simulation result of Hayashi and Prescott (2006).

Wage differential term	Sectoral nominal share term
0.27%	-5.85%

Table 2: Decomposition of the difference in the prewar and postwar baseline misallocation effects. Note: The sum is equal to the difference in the prewar and postwar misallocation effects.

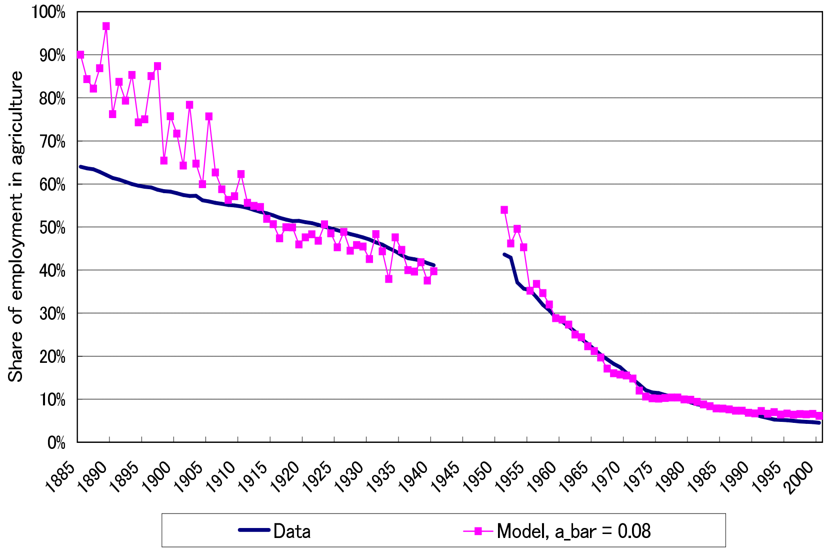

Figure 1: The data and model prediction of the Japanese agricultural employment rate.

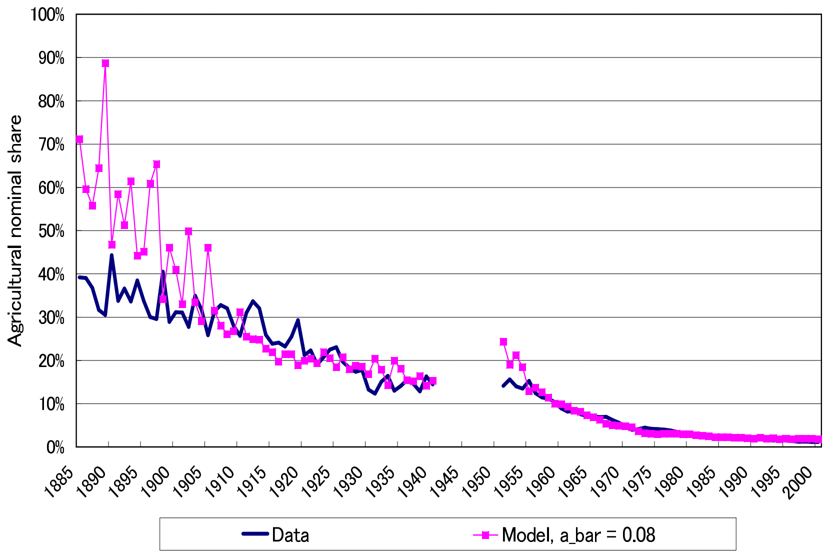

Figure 2: The data and model prediction of the Japanese agricultural nominal share.