The B.E. Journal of Macroeconomics

Topics

Volume 8, *Issue* 1 2008 *Article* 25

The Japanese Depression in the Interwar Period: A General Equilibrium Analysis

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Recommended Citation
Hikaru Saijo (2008) "The Japanese Depression in the Interwar Period: A General Equilibrium Analysis," *The B.E. Journal of Macroeconomics*: Vol. 8: Iss. 1 (Topics), Article 25.
Available at: http://www.bepress.com/bejm/vol8/iss1/art25

The Japanese Depression in the Interwar Period: A General Equilibrium Analysis*

Hikaru Saijo

Abstract

This paper studies the Japanese depression in the interwar period using the business cycle accounting methodology and a general equilibrium model with time-varying markups. I find that the initial slowdown of the economy can be explained by a decline in productivity. However, I also find that when only productivity change is taken into account, a prototype neoclassical growth model predicts that in the 1930s, output recovers more rapidly than is actually supported by the data. Using restrictions from theory, I quantify the contribution of an increase in markups in the manufacturing and mining sectors and find that a substantial fraction of the weak recovery can be explained by this factor. I argue that this increase in markups is caused by government-promoted cartelization.

KEYWORDS: cartelization, depression, Japan, productivity

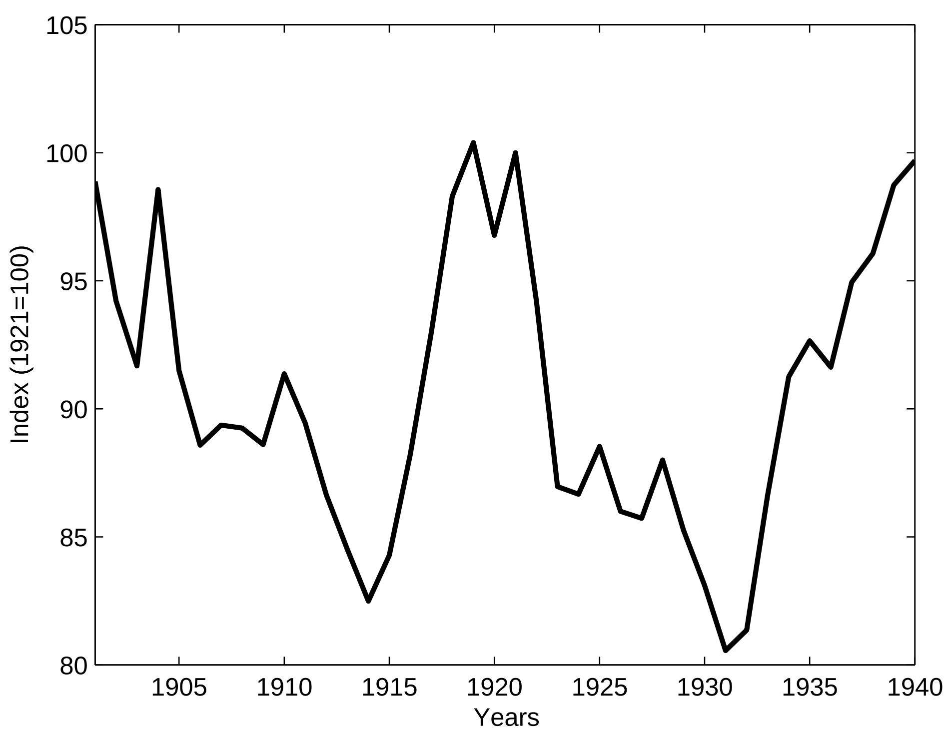
*I am especially grateful to Toni Braun for his encouragement and suggestions throughout the project. Marco Bassetto (the editor), Julen Esteban-Pretel, Fumio Hayashi, Masaru Inaba, Huiyu Li, Kengo Nutahara, Tetsuji Okazaki, Yasuhiro Omori, and two anonymous referees provided many useful comments.

1 Introduction

Japan experienced a decade-long economic stagnation throughout the 1920s, and output fell below trend by about 20% in 1931 (Figure 1). In 1932, output began to recover and came back to trend by 1940. The recovery of output, however, was weaker than the productivity growth during this period. When only productivity change is taken into account, a prototype neoclassical growth model predicts that output grows more rapidly than is actually supported by the data. Using the business cycle accounting (BCA) methodology by Chari et al. (2007) and a general equilibrium model with time-varying markups, I find that increase in markups due to rapid cartelization is a key factor in explaining the weak recovery.

The BCA methodology decomposes the fluctuations in aggregate variables to measure which of the four distortions in equilibrium conditions are important in accounting for these fluctuations. The four distortions are called the efficiency wedge, the intratemporal wedge, the intertemporal wedge, and the government consumption wedge. In principle, one can recover the actual data by feeding all these wedges

Figure 1: Detrended real per capita GNP: 1901–1940



into the prototype growth model.

By applying the BCA methodology to the Japanese economy during the period 1921–1936, I find that the fall of productivity was the main cause of the initial slowdown of the economy. I also find that a deterioration of both intra- and intertemporal wedges kept output below trend in the 1930s. In a monopolistically competitive economy with time-varying markups, fluctuations in markups manifest themselves as fluctuations in both intra- and intertemporal wedges in the prototype growth economy. I argue that in the 1930s, by limiting competition, the government-promoted cartelization raised firms' markups in the manufacturing and mining sectors.

I quantify the contribution of the government-promoted cartelization during this period by constructing counterfactual wedges that eliminate the effect of the increase in firms' markups.[1] I infer the variations in firms' markup from variations in unit costs of labor, as suggested by theory. In comparing output predicted by using the counterfactual wedges to the actual output, I find that the increase in markups accounts for about 60% to 70% of the slow recovery in the 1930s.

The research that is most closely related to this study is Kobayashi and Inaba (2006), which also applies the BCA methodology to the Japanese economy in the interwar period.[2] They find that both intra- and intertemporal wedges deteriorated from the late 1920s, and did not recover throughout the 1930s. I augment their research by identifying the major source of the deterioration of these wedges.

The present paper also contributes towards understanding prewar Japanese economic development. Hayashi and Prescott (2008) find that their model over-predicts interwar output growth and capital accumulation. They hypothesize that the rapid cartelization in the 1930s may have something to do with this. I qualitatively and quantitatively evaluate their theory and find that the cartelization had considerable depressing effects on output growth and capital accumulation.

Finally, this paper adds to the literature which examines the role of government policies during the Great Depression. Recent studies reveal that these policy changes considerably affected the economy. For example, Cole and Ohanian (2004) conclude that New Deal cartelization policies, which limited competition and raised labor bargaining power, are key towards understanding the weak recovery from the Great Depression. Fisher and Hornstein (2002) find that high real wages, resulting from the collective bargaining system, are important in accounting for Germany's Great Depression. Beaudry and Portier (2002) speculate that an institutional change, which may be the consequence of a change in government

[1] Meza (2008) studies the role of fiscal policy on the Mexican financial crisis by constructing counterfactual wedges that eliminate the effects of changes in fiscal policy.

[2] I repeat their BCA exercise in Section 3, although there are several differences in details. The most notable difference is that their model is deterministic, while mine is stochastic.

DOI: 10.2202/1935-1690.1614

policy, can explain the French depression in the 1930s. My research complements these studies by showing how much the Major Industries Control Law and the Industrial Organization Law of 1931 contributed to the weak recovery of output in Japan in the 1930s.

The rest of the paper is organized as follows. Section 2 documents some data facts about the Japanese economy between 1921 and 1936. Section 3 presents a prototype growth model and conducts a BCA exercise. Section 4 presents a model with time-varying markups and relates it to the prototype growth model. Section 5 cites some evidence of cartelization from the late 1920s and argues that this government-promoted cartelization raised firms' markups. Section 6 quantifies the role of cartelization by constructing counterfactual wedges and simulating the path of aggregate variables using these counterfactual wedges. Finally, Section 7 concludes.

2 The Japanese Economy: 1921–1936

In this section, I discuss some properties of aggregate data from 1921 to 1936. I end my analysis in 1936, since in 1937, the Sino-Japanese War began and Japan entered the wartime economy. Data sources are described in the Appendix. Most of the series (except for working hours) exhibit a trend, so it is necessary to remove the trend in these variables. As a first step, all variables are divided by the working-age (15 years and older) population. Then, I detrend the series by the trend growth rate, since neoclassical growth theory indicates that output and its components would grow at that rate on a balanced-growth path. I use the value 2.1% for the trend growth rate, which is the average growth rate of per capita GNP for the period 1901–1940.[3] Unless otherwise noted, all variables are in real terms.

Table 1 reports output and its components from 1921 to 1936. Output and private investment fell considerably in the 1920s and were at their lowest levels during the Great Depression. In fact, output was almost 20%, and investment was more than 50% below trend in 1931 and 1932, respectively. Although the economy began to recover beginning in 1932, both output and investment were still about 10% below trend in 1936. Compared to output and investment, the recovery of consumption was much weaker. Consumption in the 1930s never returned to its 1920s level. Moreover, consumption remained at more than 15% below trend as late as 1936. Optimization of the household implies that every expectation of future income should be incorporated into present consumption. This observation suggests that the economy was hit by a persistent shock which depressed household con-

[3] The average growth rate for the period 1901–1921 was also 2.1%.

Table 1: Output and its components

Year	Output	Con.	Inv.	Gov. Con.	Exports	Imports
1922	94.2	102.8	85.9	95.4	116.3	115.3
1923	87.0	101.1	62.6	84.1	**97.4**	113.7
1924	86.7	99.6	76.5	78.2	118.4	126.3
1925	88.5	98.1	76.2	**76.4**	139.1	111.4
1926	86.0	96.0	77.5	78.2	139.5	121.3
1927	85.7	95.2	76.4	84.6	149.7	120.7
1928	88.0	94.5	70.1	93.0	151.7	115.9
1929	85.3	90.5	74.6	87.7	161.3	118.6
1930	83.1	87.7	71.2	80.8	147.0	**96.9**
1931	**80.6**	86.5	56.2	90.4	140.1	102.7
1932	81.4	**82.4**	**48.7**	98.5	161.2	97.8
1933	86.6	85.2	58.1	101.5	176.3	99.1
1934	91.3	87.8	74.7	94.3	208.4	108.5
1935	92.7	84.5	84.6	94.8	244.8	109.1
1936	91.6	83.9	88.5	93.7	253.1	114.4

Notes: 1921 = 100. All variables are detrended. **Bold types** indicate their lowest levels.

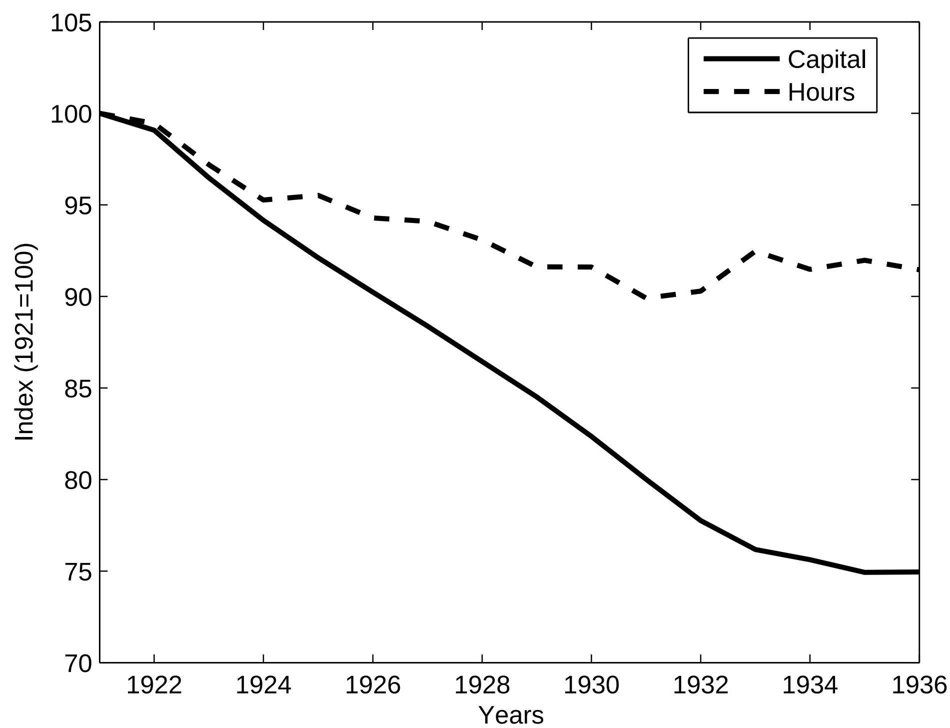
sumption.[4] The level of government consumption was at its lowest in the mid-1920s and at its highest around 1932 and 1933. Imports, and especially exports, were in good shape. Imports grew at the trend rate during most of the period, and exports, by 1936, grew by more than twice the 1921 level. This suggests that the depression was caused by domestic, rather than international factors.

Figure 2 reports inputs. Net (net of depreciation) private capital stock continued declining during the period. Total working hours also fell considerably in the 1920s and reached its lowest levels during the Great Depression. In particular, hours barely increased while the output recovered. This is puzzling as standard real business cycle models (as in Prescott, 1986) predict that hours should rise during expansions. I will show in this paper that increase in markups in the manufacturing and mining sectors can account for this puzzle.

[4] Cole and Ohanian (1999) report a similar observation in their study of the Great Depression in the United States.

DOI: 10.2202/1935-1690.1614

Figure 2: Private capital stock and total working hours



3 Business Cycle Accounting Results

In this section, I present a prototype growth economy and perform a BCA exercise. The exercise allows me to identify which distortions on equilibrium conditions contributed to the fluctuations in the economy during the interwar period.[5]

The representative household has preferences over consumption C_t, and leisure $1-H_t$:

$$E_0 \sum_{t=0}^{\infty} \beta^t [\ln C_t + \psi \ln(1-H_t)]. \tag{1}$$

The household constraints are

$$C_t + I_t = \tau_t^w w_t H_t + \tau_t^r r_t K_{t-1} + TR_t, \tag{2}$$

$$K_t = I_t + (1-\delta) K_{t-1} \tag{3}$$

[5]Throughout the paper, I use $\widetilde{x}_t$ to express the log-deviation of variable x from its steady-state value $\bar{x}$ at time t.

where K_t is the capital stock at the end of the period t, I_t is investment, w_t is the wage rate, r_t is the rental rate of capital, and TR_t is a lump-sum transfer from the government. Capital depreciates at rate δ. τ_t^w and τ_t^r are the intra- and intertemporal wedges, respectively.[6] These wedges represent distortions on the household's intra- and intertemporal first-order conditions.

The representative firm's production function is $Y_t = z_t K_{t-1}^{\alpha}(X_t H_t)^{1-\alpha}$. Here $z_t X_t^{1-\alpha}$ is total factor productivity (TFP), where z_t is the efficiency wedge and X_t is a labor-augmenting deterministic trend that follows the law of motion: $X_t = \gamma X_{t-1}$. The firm solves the standard profit maximization problem, taking r_t and w_t as given. The flow government budget constraint is $G_t = -TR_t + (1-\tau_t^w)w_t H_t + (1-\tau_t^r)r_t K_{t-1}$, where G_t is the government consumption wedge.

Then, the following (detrended) equations characterize the equilibrium in this economy.

$$\frac{\tau_t^w(1-\alpha)\widehat{Y}_t/H_t}{\widehat{C}_t} = \frac{\psi}{1-H_t}, \tag{4}$$

$$\frac{\gamma}{\widehat{C}_t} = \beta \mathrm{E}_t\left[\left(\frac{1}{\widehat{C}_{t+1}}\right)\left(\tau_{t+1}^r \alpha \widehat{Y}_{t+1}/\widehat{K}_t + 1 - \delta\right)\right], \tag{5}$$

$$\widehat{Y}_t = z_t \widehat{K}_{t-1}^{\alpha} H_t^{1-\alpha}, \tag{6}$$

$$\widehat{Y}_t = \widehat{C}_t + \widehat{I}_t + \widehat{G}_t, \tag{7}$$

$$\gamma \widehat{K}_t = \widehat{I}_t + (1-\delta)\widehat{K}_{t-1} \tag{8}$$

where $\widehat{C}_t = C_t/X_t$, $\widehat{Y}_t = Y_t/X_t$, $\widehat{K}_{t-1} = K_{t-1}/X_t$, $\widehat{I}_t = I_t/X_t$, $\widehat{G}_t = G_t/X_t$. These conditions will be log-linearized around the steady state.

To back out wedges from the data, it is necessary to specify the stochastic process governing the wedges as well as the parameter values. The leisure weight parameter ψ is set to 1.8.[7] The depreciation rate δ is set to 0.061. This is the average depreciation rate calculated from the data. Capital's share of income was 0.322 in 1920–29, and 0.387 in 1930–39 (Minami and Ono, 1979, Table 11.6.), so I take the mean value of the two and set α to 0.355. β is set to 0.96, which implies an annual interest rate of about 4%. γ is set to match the average growth rate of real per capita GNP for the period 1901–1940. The steady-state values of efficiency wedges $\bar{z}$, and government consumption wedges $\overline{G}$, are set to the actual values obtained from the 1921 data. According to my measure of total working hours, households allocated about 27% of their time to work in 1921. Therefore, the steady-state value of intratemporal wedges $\overline{\tau}^w$, is set so that the household allocates about 27% of their

[6] Although this definition of intertemporal wedge differs slightly from the one defined in Chari et al. (2007), they note that this alternative definition does not significantly change the results.

[7] Chari et al. (2007) and Kersting (2008) set the value to 2.24 and 1.5, respectively.

DOI: 10.2202/1935-1690.1614

time to work in the steady state. The steady-state value of intertemporal wedges $\overline{\tau}^r$, is set so that the steady-state capital-output ratio is equal to the actual capital-output ratio in 1921.

Log-deviations of the four wedges from their steady states, $\widetilde{\mathbf{s}}_t = (\widetilde{z}_t, \widetilde{\tau}^w_t, \widetilde{\tau}^r_t, \widetilde{G}_t)'$, are assumed to follow an VAR(1) process of the form

$$\widetilde{\mathbf{s}}_t = \mathbf{P}\widetilde{\mathbf{s}}_{t-1} + \varepsilon_t \tag{9}$$

where the shock ε_t is independent and identically distributed from a normal distribution with mean zero and covariance matrix $\mathbf{V}$. I estimate the lower triangular matrix $\mathbf{Q}$, where $\mathbf{V} = \mathbf{Q}\mathbf{Q}'$, to ensure that my estimate of $\mathbf{V}$ is positive semidefinite. Bayesian estimates of the parameters of this VAR(1) process (9) are given in the Appendix.

I assume that the economy was at the steady state in 1921. I measure government consumption wedges directly from the government consumption data.[8] Following Chari et al. (2007), I use the data and the model's decision rules in order to obtain the values of other wedges. With $\widetilde{Y}^d_t$, $\widetilde{H}^d_t$, $\widetilde{I}^d_t$, $\widetilde{G}^d_t$, and $\widetilde{K}^d_{t-1}$ denoting data, and $\widetilde{Y}(\widetilde{\mathbf{s}}_t, \widetilde{K}_{t-1})$, $\widetilde{H}(\widetilde{\mathbf{s}}_t, \widetilde{K}_{t-1})$, and $\widetilde{I}(\widetilde{\mathbf{s}}_t, \widetilde{K}_{t-1})$ denoting the decision rules derived using the method of Uhlig (1997), the measured wedge series $\widetilde{\mathbf{s}}^d_t$ solves

$$\widetilde{Y}^d_t = \widetilde{Y}(\widetilde{\mathbf{s}}^d_t, \widetilde{K}^d_{t-1}), \quad \widetilde{H}^d_t = \widetilde{H}(\widetilde{\mathbf{s}}^d_t, \widetilde{K}^d_{t-1}), \quad \widetilde{I}^d_t = \widetilde{I}(\widetilde{\mathbf{s}}^d_t, \widetilde{K}^d_{t-1}) \tag{10}$$

with $\widetilde{G}_t = \widetilde{G}^d_t$.

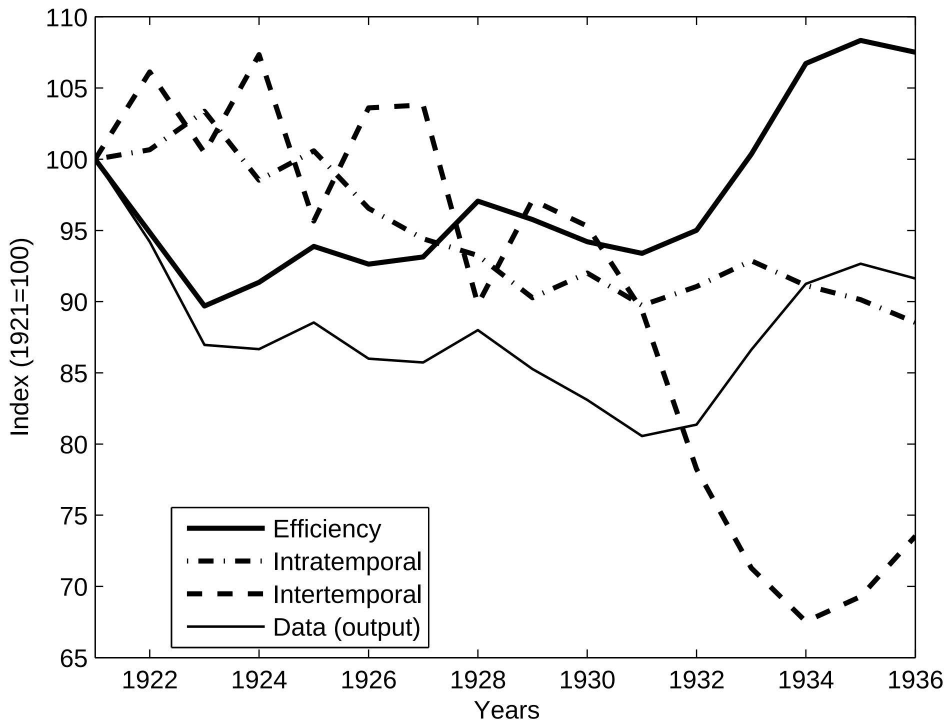
Figure 3 reports the measured wedges. Since government consumption wedges are available from Table 1, I do not report them in the Figure. There are two things to observe. First, the efficiency wedge dropped by 10.3% in the early 1920s and gradually recovered. Second, both intra- and intertemporal wedges declined from the late 1920s, and stayed substantially low throughout the 1930s.

In Figure 4, I plot the model's prediction for output when the model includes only one wedge. In these experiments, I simulate the model by allowing only one wedge to fluctuate, setting others to their steady-state values. For comparison, I also plot the actual data for output. With efficiency wedge alone, output declines by 13.2% from 1921 to 1923. This suggests that the fall in productivity is the most important factor in accounting for the initial slowdown of the economy.[9] However, with the efficiency wedge alone, the model output predicts a much faster recovery

[8]Following Chakraborty (2008), I add net exports to private consumption. I do not add net exports to goverment consumption as in Chari et al. (2007), since this creates unusually large variations in government consumption wedges and the performance of the log-linear approximation would become poor. Consequently, the private consumption is defined as (output) − (private investment) − (government consumption). Note that the definition is different from the one used in Table 1.

[9]A particularly large drop in productivity occured in 1923, when the Great Kanto Earthquake

Figure 3: Measured wedges



than the data. In 1936, the predicted output is 8.8% above trend. In sharp contrast, the actual output stays 8.4% below trend. The predicted output shows a much different picture with intra- or intertemporal wedges alone. With these wedges alone, predicted output gradually declines from the late 1920s, and remains low after the Great Depression. The government consumption wedge plays only a modest role in accounting for output. These results suggest that, as Kobayashi and Inaba (2006) argue, understanding why both intra- and intertemporal wedges declined and did not recover in the 1930s, is important for explaining the Japanese depression in the interwar period.

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hit the capital Tokyo. The loss in human resources and corporate failures due to the earthquake may have reduced organizational capital (Ohanian, 2001), the knowledge and know-how firms use to organize production, and hence reduced productivity. On the other hand, Fumio Hayashi pointed out the possibility that the capital stock series in *LTES* (the main data source of this paper) does not correctly take into account the destruction of capital by the earthquake. The overestimation of the capital stock would cause an underestimation of the true productivity.

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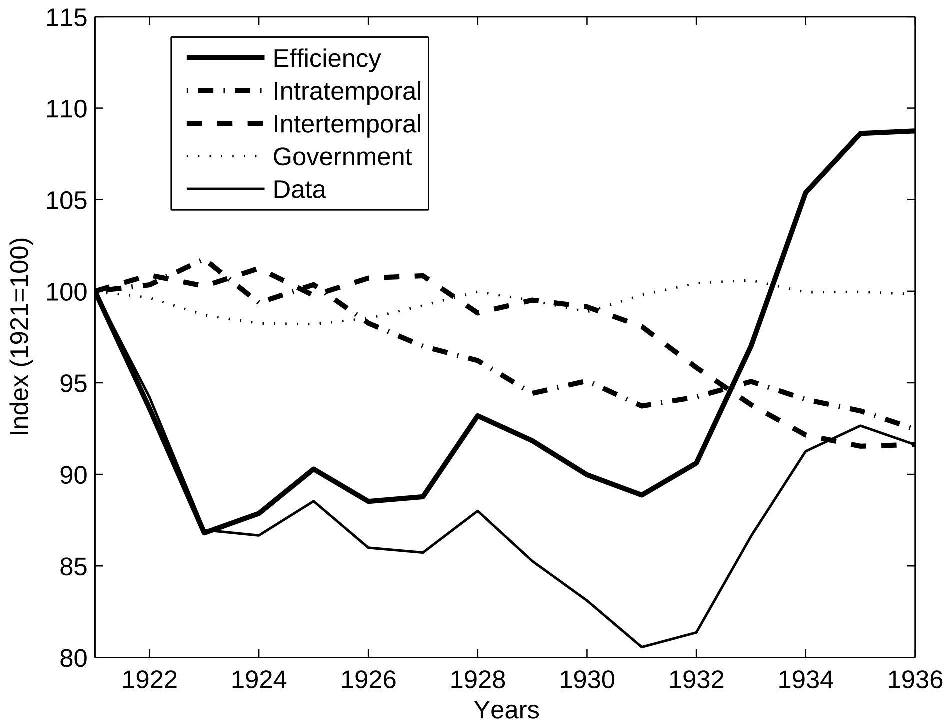
Figure 4: Decomposition of output with only one wedge



4 A Model With Time-varying Markups

Now I describe a general equilibrium model with time-varying markups.[10] Variations in markups can be interpreted as variations in the degree of competition among firms. I show that changes in markups in this model manifest themselves as changes in intra- and intertemporal wedges in the prototype model.

Consider an economy similar to the one presented in the previous section, but there are a continuum of perfectly competitive final-goods firms and a continuum of monopolistically competitive intermediate-goods firms on the production side.

The household maximizes (1) subject to (3) and

$$C_t + I_t = w_t H_t + r_t K_{t-1} + TR_t + \int_0^1 \pi_t(i)di \tag{11}$$

where $\pi_t(i)$ is profit from intermediate-goods firm i.

[10] Christiano et al. (2003) also consider stochastic variations in markups.

Perfectly competitive final-goods firms combine intermediate goods and produce according to

$$Y_t = \left[\int_0^1 Y_t(i)^{q_t} di \right]^{\frac{1}{q_t}} \tag{12}$$

where $Y_t(i)$ is the input of intermediate good i and $0 < q_t \leq 1$. The smaller that q_t is, the more market power intermediate-goods firms have, since a smaller value of q_t implies that intermediate goods are less substitutable for each other. I allow this q_t to change over time.

Profit maximization by final-goods firms yields the following input-demand functions for intermediate goods:

$$Y_t(i) = \left[\frac{P_t}{P_t(i)} \right]^{\frac{1}{1-q_t}} Y_t \tag{13}$$

where P_t is the price of final goods and $P_t(i)$ is the price of intermediate good i. The zero-profit condition implies that

$$P_t = \left[\int_0^1 P_t(i)^{\frac{q_t}{q_t-1}} di \right]^{\frac{q_t-1}{q_t}}. \tag{14}$$

Each intermediate-goods firm has access to the following Cobb-Douglas production technology:

$$Y_t(i) = z_t (K_{t-1}(i))^{\alpha} (X_t H_t(i))^{1-\alpha}. \tag{15}$$

Each firm maximizes its profits, subject to equations (13) and (15). This yields the following relations of labor and capital demand:

$$w_t/P_t(i) = q_t(1-\alpha)Y_t(i)/H_t(i), \tag{16}$$

$$r_t/P_t(i) = q_t \alpha Y_t(i)/K_{t-1}(i). \tag{17}$$

In a symmetric equilibrium, $P_t(i) = P_t, Y_t(i) = Y_t, H_t(i) = H_t, K_{t-1}(i) = K_{t-1}, \forall i$, so

$$w_t = q_t(1-\alpha)Y_t/H_t, \tag{18}$$

$$r_t = q_t \alpha Y_t/K_{t-1} \tag{19}$$

by normalizing $P_t = 1$ for all t. Here q_t drives a wedge between factor prices and marginal products. The markup rate for each intermediate-good firm is given by $1/q_t$.

DOI: 10.2202/1935-1690.1614

Combining equations (18) and (19) with the household's first-order conditions, I obtain

$$\frac{q_t(1-\alpha)\widehat{Y}_t/H_t}{\widehat{C}_t} = \frac{\psi}{1-H_t}, \tag{20}$$

$$\frac{\gamma}{\widehat{C}_t} = \beta \mathrm{E}_t\left[\left(\frac{1}{\widehat{C}_{t+1}}\right)\left(q_{t+1}\alpha\widehat{Y}_{t+1}/\widehat{K}_t + 1 - \delta\right)\right]. \tag{21}$$

Thus, I have proven the following:

Proposition 1: *Consider a prototype economy described in Section 3 with intra- and intertemporal wedges given by*

$$\tau_t^w = \tau_t^r = q_t \tag{22}$$

where q_t is the inverse of the markup from the detailed economy with time-varying markups. Then the equilibrium allocations for aggregate variables in the detailed economy are equilibrium allocations in this prototype economy.

Suppose that in this detailed economy there are some periods where markups of intermediate-goods firms increase. The outside observer who tries to fit the data generated by the detailed economy would see deteriorations in both intra- and intertemporal wedges. This deterioration of these wedges is exactly what we saw in the previous section. Was there really an increase in markups in the Japanese economy during this period? If so, why did the increase occur? These issues are treated in the next section.

5 Cartelization and the Major Industries Control Law

From the late 1920s to the early 1930s, the number of cartels increased significantly in manufacturing, mining, and financial sectors (Table 2). Moreover, an important change in government policies toward cartels took place in the 1930s. Government promoted cartelization through the Major Industries Control Law (hereafter MICL) and the Industrial Organization Law of 1931. I argue that this government-promoted cartelization limited competition, raised prices, and hence raised firm's markups considerably.[11]

[11] In contrast to Cole and Ohanian (2004) and Fisher and Hornstein (2002), I do not consider the role of changes in labor bargaining power in this paper, as the MICL did not include provisions to raise wages and it is not clear how the law affected labor bargaining power.

Table 2: The number of major cartels: 1921–1932

Year	1921	···	1925	1926	1927	1928	1929	1930	1931	1932
Number	15	···	20	22	31	37	42	62	86	94

Notes: Calculated from Takahashi (1933), pp. 121–127.

The Major Industries Control Law

The government at that time believed that the difficulties beginning in the 1920s were due to excessive competition among firms. It argued that some kind of administrative intervention was needed for recovery:

> The objective of the MICL is to control domestic industries appropriately in view of the current situation, remove the sources of their instability, ... and bring prosperity to our economy. [Special Bureau of Industry Rationalization (1932), preamble]

The establishment of the law was also supported by the cartels. Many cartels, including those in cement, flour milling, and steel industries, requested that the MICL cover their industries. As a result, more than 20 industries were classified as the target industries of the law. The cornerstone of the MICL was a provision for cartel enforcement. This was stated in Article 2. With petitions from more than two-thirds of participants of the cartel agreement, it allowed the government to order both participants and *non*-participants of the agreement to follow the agreement. The Industrial Organization Law was a version of the MICL which aimed at relatively smaller cartels. It also had a provision for cartel enforcement. These laws gave the government significant power in promoting cartel activities and enforcing cartel arrangements. Many studies, including Ikeda (1982), Ministry of Commerce and Industry (1961), and Miyajima (1990), conclude that these cartelization policies had significant impact on the performance of the cartels.

Findings From the Previous Literature

Tominaga (1982) carries out statistical tests to see whether the cartelized industries enjoyed greater profits than the non-cartelized industries. As his paper is in Japanese, I summarize his results here. For 79 industries, for which there was sufficient data, he classifies 18 industries as cartelized industries and 61 industries as non-cartelized industries.[12] First, he conducts a t-test to investigate whether average profit rates in cartelized and non-cartelized industries differ. In all periods (1926–1929, 1930–1931, and 1933–1936) the profits in cartelized industries are greater than those of non-cartelized industries. Although the differences are not statistically significant in the first two subperiods, they become significant after 1933. He also conducts a χ^2-test of independence and obtains similar results. Second, he compares the cartel goods price index with the overall industrial goods price index. Before 1932, the cartel goods price index moves along with the industrial goods price index. After 1932, however, the cartel goods price becomes relatively higher. For example, the cartel goods price is 12% higher than the overall industrial goods in 1936. Based on these tests and data, Tominaga (1982) concludes that there was a considerable cartel effect on the economy after 1932.

Minobe (1931)[13] provides a detailed analysis of the cartelization from the late 1920s. He emphasizes that the market power of cartels increased after the financial panic in 1927:

> The financial panic in 1927 ... was a process of concentration of production and capital. ... We can find a number of characteristics in cartels after the financial panic in 1927, whose operations became very active. First, the power of cartels became greater in terms of quantity because of the rise in production control rates. Second, the control of cartels spread in larger regions since many cartels emerged in areas where there was no cartel before. Third, the power of cartels became greater in terms of quality since many new collective sales unions were formed. [Minobe (1931), pp. 589–590]

He also argues that the cartel prevented prices from dropping during the Great Depression:

> Despite the worsening of the Great Depression and the striking decline in the quantity of goods circulated, prices rose in the first half of 1931. As many people point out, production control and price arrangement by cartels are the cause. [Minobe (1931), p. 596]

There are already a number of industry-level studies investigating Japanese cartels in the interwar period. The general conclusion of this literature is that the cartels played an important role by limiting competition and raising prices. For example, Okazaki (1985) notes that the steel cartel was able to enjoy stable markups

[12] It is important to note that even in industries classified as non-cartelized, some form of production control took place. Therefore these tests are conservative estimates of the cartel effects.

[13] Minobe is a Japanese economist, who served as Governor of Tokyo after WWII.

by setting minimum prices starting around 1930. Takeda (1985) reports that the superphosphate cartel raised prices by cutting production. Motomiya (1985) documents that the flour milling cartel sustained high profits by controlling both material and product prices.

Wages Were Unusually Low

The time-varying markup model presented in Section 4, generates some predictions regarding the relationship between factor prices and marginal products. In particular, holding marginal products constant, it predicts that wages decrease as markups increase.

Figure 5 reports Japanese and US manufacturing real wage rates in the 1930s.[14] In the US, real wages were about 10% above trend during the mid 1930s. Cole and Ohanian (1999) cite this fact as evidence of their cartelization story accompanied by the rise in union power. In sharp contrast, real wages were significantly below trend in Japan.[15] This fact is particularly noteworthy since the 1930s was a period of rapid productivity growth in Japan. This fact is also consistent with the story that cartelization raised markups and was not associated by an increase in labor bargaining power. It is interesting that some people in those days realized that the wage rate was unusually low. See, for example, the July 17th article of the Osaka Asahi Newspaper (1936).

The evidence presented so far suggests that cartels raised firms' markups without increasing the labor bargaining power throughout the late 1920s and 1930s. It also shows that the power of the cartels peaked in the mid 1930s, after the government established the MICL.

6 Quantifying the Effects of Cartelization

This section quantifies the effects of cartelization on output and other aggregate variables. I first construct counterfactual wedges which eliminate the changes in markups. I then compare aggregate variables in the data to those obtained using the counterfactual wedges.

I first describe how to decompose the intra- and intertemporal wedges into two parts, one of which is related to the markups. I use restrictions from the model to

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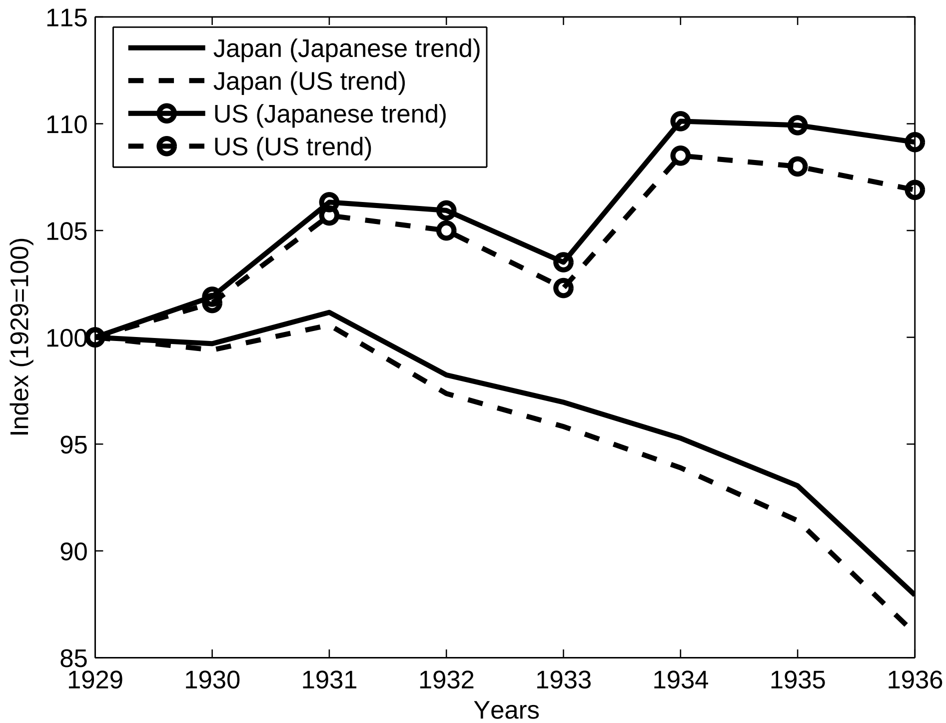
[14] I thank Marco Bassetto for suggesting that I examine the wage-rate data.

[15] This result may be sensitive to the choice of the price index one uses to deflate wages. As a robustness check, I also deflated the Japanese wage series using the consumer price index. I obtained a quite similar result.

DOI: 10.2202/1935-1690.1614

Figure 5: Real detrended manufacturing wages in Japan and the US



Notes: US manufacturing wage is taken from Cole and Ohanian (1999), Table 11. The series labeled *Japanese trend* is detrended with a 1.6% trend, which is the average growth rate of Japanese real manufaturing wages in 1901–1919. I ignored 1920 since there was an unusually large increase in the manufacturing wage this year. The series labeled *US trend* is detrended with a 1.9% trend, following Cole and Ohanian (1999). All series are deflated by the GNP deflator.

back out implied markups from observables.[16]

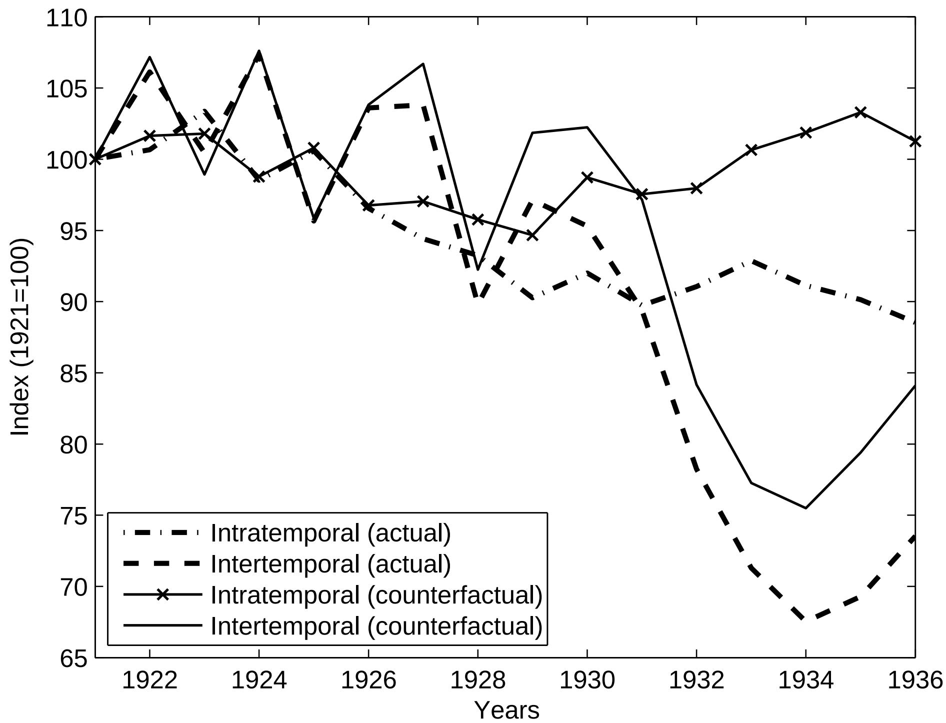
Using equation (18), the markup $1/q_t$ is given by the ratio of the marginal product of labor to the wage rate:

$$\frac{1}{q_t} = \frac{(1-\alpha)Y_t/H_t}{w_t} = \frac{1-\alpha}{l_t} \tag{23}$$

where $l_t \equiv w_t H_t / Y_t$ is the unit cost of labor. It is clear from this equation that q_t is

[16] Gali and Gertler (1999) use a similar approach to measure real marginal costs from the data.

Figure 6: Counterfactual intra- and intertemporal wedges



proportional to l_t.

In this experiment I treat only the manufacturing and mining sectors as cartelized and assume that markups in other sectors did not change throughout the period. The inverse of the aggregate markups q_t, which I call the markup wedge, is defined as

$$q_t = \text{share}_t q_t^m + (1 - \text{share}_t)\overline{q} \tag{24}$$

where share_t is the manufacturing and mining share of output in period t, q_t^m is the inverse of markups in the manufacturing and mining sectors estimated from equation (23), and $\overline{q}$ is the steady-state value of the inverse of markups.[17] For example, $\text{share}_{1936} = 0.29$, i.e., the manufacturing and mining share of output in 1936 is 29%. I detrend real manufacturing wages by a 1.6% trend.[18]

[17] I set $\overline{q} = 1$. I believe this is an appropriate value since it relates each sector's markups to aggregate markups, proportional to its share in total output.

[18] Cole and Ohanian (2004) detrend real manufacturing wages by a 1.4 % trend. This is the average growth rate in manufacturing compensation during the postwar period.

DOI: 10.2202/1935-1690.1614

To decompose the intra- and intertemporal wedges to markup wedges and counterfactual wedges, I extend equation (4) and (5) as follows:[19]

$$\tau_t^w = \frac{\widehat{C}_t \psi}{(1-H_t)\widehat{w}_t} \cdot \frac{\widehat{w}_t}{(1-\alpha)\widehat{Y}_t/H_t}, \quad (25)$$

$$\mathrm{E}_t \tau_{t+1}^r = \mathrm{E}_t \left[\frac{\gamma \widehat{C}_{t+1}/(\beta \widehat{C}_t) - 1 + \delta}{r_{t+1}} \cdot \frac{r_{t+1}}{\alpha \widehat{Y}_{t+1}/\widehat{K}_t} \right] \quad (26)$$

where $\widehat{w}_t = w_t/X_t$. The first argument on the right hand side of the above equations stands for intra- and intertemporal distortions on the household side. The second stands for distortions on the firm side, which I explicitely model as variations in markups. The two equations can be further rewritten as follows:

$$\tau_t^w = \tau_t^{w*} q_t, \quad (27)$$

$$\mathrm{E}_t \tau_{t+1}^r = \mathrm{E}_t [\tau_{t+1}^{r*} q_{t+1}] \quad (28)$$

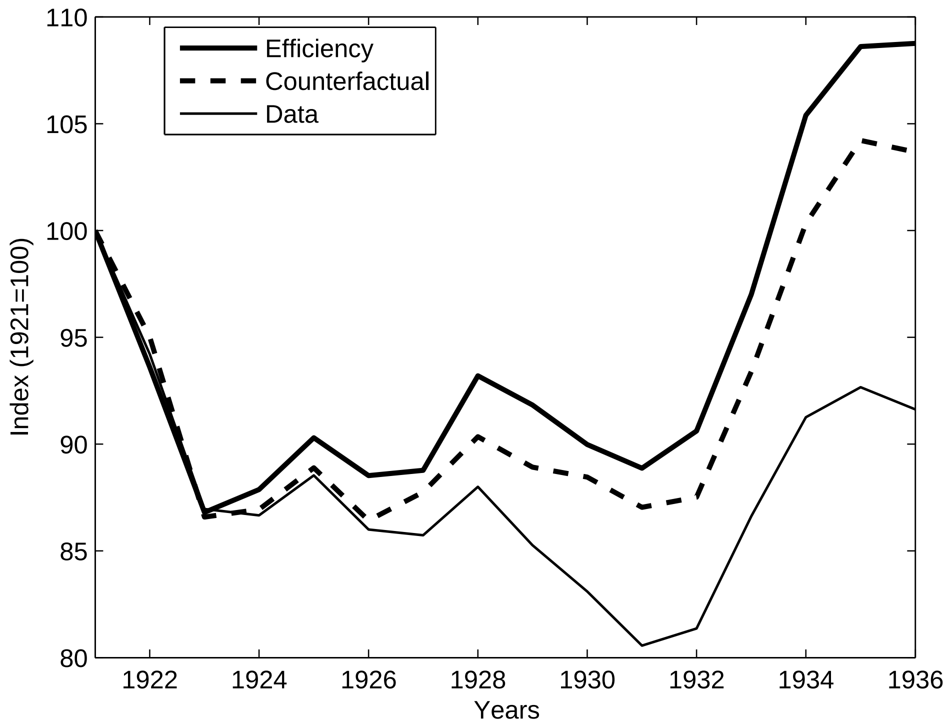
where τ_t^{w*} and τ_{t+1}^{r*} are counterfactual intra- and intertemporal wedges, respectively. These counterfactual wedges represent distortions due to forces other than the markups. Consider, for example, an increase in markups in period t. This increase would drive the value of the markup wedge q_t down and raise the values of counterfactual wedges τ_t^{w*} and τ_t^{r*}, holding the actual wedges τ_t^w and τ_t^r constant. In other words, if it were not for the increase in markups, there would be less intra- and intertemporal distortions.

Figure 6 reports counterfactual intra- and intertemporal wedges calculated using (27) and (28). It shows that a significant portion of the fall of wedges can be explained by increase in markups. In particular, keeping markups constant, intratemporal wedges stay around the trend level for most of the period.

I now compare the paths of aggregate variables in the data to those predicted by the counterfactual wedges. In this counterfactual experiment I feed into the model $\widetilde{\mathbf{s}}_t^* = (\widetilde{z}_t, \widetilde{\tau}_t^{w*}, \widetilde{\tau}_t^{r*}, \widetilde{G}_t)'$ which captures distortions in equilibrium conditions while keeping aggregate markups constant after 1921. Note that I feed in the actual efficiency and government consumption wedges in this simulation. I assume that households expect that wedges follow the same VAR(1) process as the one in Section 3. Figures 7 and 8 report aggregate variables in the data (labeled *Data*) and those predicted using counterfactual wedges $\widetilde{\mathbf{s}}_t^*$ (labeled *Counterfactual*). The predicted path using the efficiency wedge only (labeled *Efficiency*) is also reported. The figures show that simulated variables using counterfactual wedges are considerably higher than the data, which suggests that the increase in markups can explain a substantial portion of the weak recovery in the 1930s.

[19] I thank a referee for suggesting this decomposition.

Figure 7: Predicted path of output using counterfactual wedges

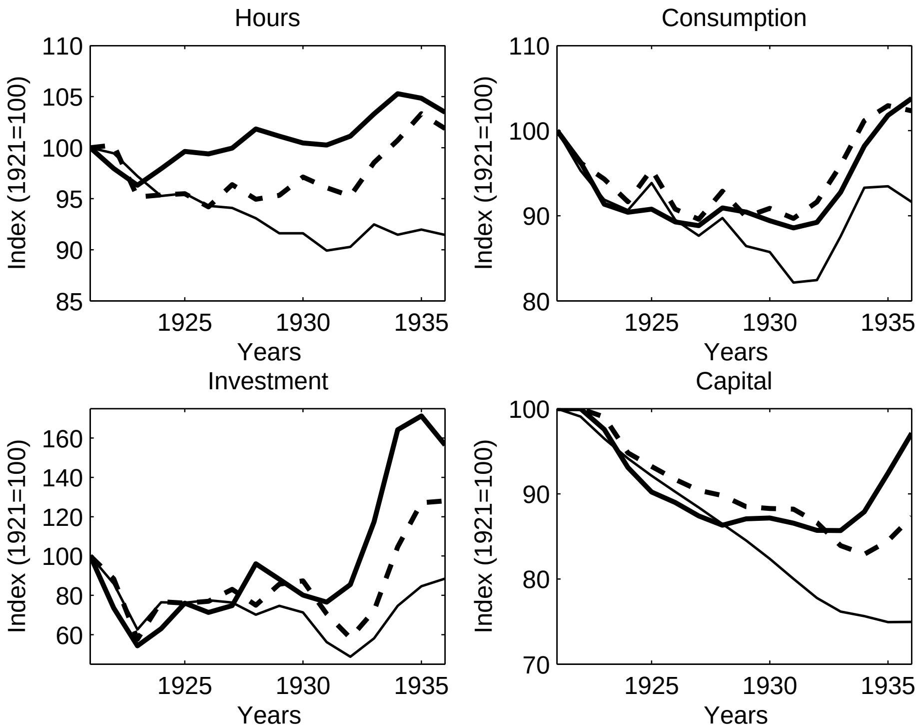


According to Figure 7, output in 1934 is 8.7% below trend in the data, and 5.4% above trend with the efficiency wedge only. The counterfactual wedge makes output 0.3% above trend in 1934. Hence the increase in markups can account for $((100.3-91.3)/(105.4-91.3)=)$ 64.2% of the low output relative to productivity in 1934. Similarly, markups can account for 72.5% and 70.3% of the low output in 1935 and 1936, respectively. Thus I conclude that the increase in markups can account for about 60% to 70% of the slow recovery of output in the 1930s.[20]

The increase in markups has a considerable effect on other variables (Figure 8). It explains 86.6% and 88.1% of low working hours and consumption in 1936, respectively. However, some fraction of low investment and capital stock is left unexplained by the increase in markups. For example, markups explain 58.2% of the dispersion between the actual investment and the predicted investment with

[20]When I detrend the manufacturing wage by a 2.1% trend (the rate that is consistent with balanced growth), the contribution of markups to the slow recovery becomes larger. The increase in markups can explain 71.8%, 80.2%, and 78.0% of the slow recovery of output in 1934, 1935, and 1936 respectively.

Figure 8: Predicted path of other aggregate variables using counterfactual wedges



efficiency wedge only, in 1936. Also, markups can account for only 55.7% of low capital stock in 1936. This is because, as shown in Figure 6, counterfactual intertemporal wedges are still substantially lower than trend in the 1930s.

7 Conclusion

This paper has studied the Japanese depession in the interwar period using the BCA methodology and a general equilibrium model with time-varying markups. When only productivity change is taken into account, the prototype neoclassical growth model predicts that in the 1930s, output recovers more rapidly than it actually does in the data. Following the approach proposed by Meza (2008), I quantify the contribution of the increase in aggregate markups due to the cartelization by constructing counterfactual wedges. I conclude that it can explain about 60% to 70% of the slow recovery of output.

The analysis in Section 6 reveals that, although the increase in markups can explain most of the decline in intratemporal wedges, it can only partially account for the decline in intertemporal wedges. It may be interesting to explore the quantitative implication of incorporating investment-specific technological progress into the model as in Fisher (2006).

Appendix

Data Sources

Two major data sources in this paper are Hayashi and Prescott (2008) and Ohkawa (known as *Long Term Economic Statistics*) hereafter referred to as *LTES*.

I use real GNP series as a measure of output. This is taken from Table 23 in Volume 1 of *LTES*. The series of private consumption and private investment are available in Table 18 and 21 in Volume 1 of *LTES* respectively. Government consumption series is constructed by summing up general government consumption expenditure and gross fixed capital formation (both series are available in Table 18 in Volume 1 of *LTES*) and then subtracting private investment. Exports and imports are taken from commodity exports of Table 3 and commodity imports of Table 4, both of which can be found in Volume 14 of *LTES*. The GNP deflator is constructed by dividing nominal GNP (Table 8 in Volume 1 of *LTES*) by real GNP. The consumer price index series is taken from Table 2 in Volume 8 of *LTES*.

To obtain net private capital stock, I first calculate the private fraction of gross aggregate capital stock, x. This is calculated from the series of gross private capital stock (`JK102_001`) and gross government capital stock (`JK102_003`) available on the Hitotsubashi University's website.[21] Then the net private capital stock is the net aggregate capital stock (taken from Table 1 in Volume 3 of *LTES*) times x.

I calculate the working-age (15 years and older) population from Table 1 (1901–1920) and 2 (1920–1940) in Volume 2 of *LTES*, and the number of workers in the agricultural and non-agricultural sectors from Table 6 and 9 in Volume 2 of *LTES*. The sector share of workers in total population is defined as the number of workers in a sector divided by the working-age population. Both agricultural and non-agricultural weekly hours (average hours worked by a worker in a week) are taken from Hayashi and Prescott (2008). Since data for manufacturing hours is not available for 1921 and 1922, I set them to the 1923 value following Hayashi and Prescott (2008). Total working hours are calculated by adding up the product of each sector's share of workers and weekly hours and then dividing by $(24\text{hours} \times 7\text{days} =)168$.

The nominal manufacturing wages are taken from Table 25 in Volume 8 of *LTES*. The real manufacturing wages are then obtained by dividing them by the

[21] `http://rcisss.ier.hit-u.ac.jp/cgi-bin/Ltes.`

DOI: 10.2202/1935-1690.1614

GNP deflator. Since the data for mining wages is not available, I assume that they are equal to the manufacturing wages. I calculate the manufacturing and mining share of output by dividing the GDP of manufacturing and mining by GDP of the total economy, taken from Table 25 in Volume 1 of *LTES*. Manufacturing and mining output is simply real GNP times manufacturing and mining share of output. Total working hours in manufacturing and mining sectors are defined as the product of the manufacturing and mining share of workers in total population and weekly hours in non-agricultural sector, divided by 168.

Parameters of the VAR(1) Process

The data used for the estimation of the VAR(1) process (9) is 1921–1940 annual data on output, working hours, investment, and government consumption. Following Chari et al. (2007), the covariance between the shocks to the government consumption wedge and those to the other wedges is restricted to be zero. This restriction avoids having the large movements in government consumption in the late 1930s to dominate the estimation of the stochastic process.

Since there is only small sample of data, I use a Bayesian procedure rather than a standard maximum likelihood procedure. The prior for diagonal terms of matrix **P** is assumed to follow a beta distribution with mean 0.7 and standard deviation 0.2. The prior for non-diagonal terms of matrix **P** is assumed to follow a normal distribution with mean 0 and standard deviation 0.3. The prior for diagonal terms of matrix **Q** is assumed to follow an uniform distribution between 0 and 0.5. The prior for non-diagonal terms of matrix **Q** is assumed to follow an uniform distribution between -0.5 and 0.5. I employ a random-walk Metropolis-Hastings algorithm (Chib and Greenberg, 1995) to draw 210,000 sample draws from the posterior distribution. The first 10,000 draws are discarded as a burn-in period. To ensure stationarity of the VAR(1) process, I discard a posterior draw whenever the maximum eigenvalue of **P** exceeds 1. I report the posterior mean for each element of **P** and **Q** below. 90% intervals of their sample draws are reported in parentheses.

$$\mathbf{P} = \begin{bmatrix} \underset{(0.732,0.979)}{0.875} & \underset{(-0.112,0.088)}{-0.012} & \underset{(-0.221,-0.002)}{-0.085} & 0 \\ \underset{(-0.034,0.239)}{0.099} & \underset{(0.891,0.996)}{0.959} & \underset{(0.036,0.208)}{0.113} & 0 \\ \underset{(0.023,0.634)}{0.314} & \underset{(-0.175,0.199)}{0.012} & \underset{(0.631,0.978)}{0.839} & 0 \\ 0 & 0 & 0 & \underset{(0.524,0.905)}{0.727} \end{bmatrix},$$

$$\mathbf{Q} = \begin{bmatrix} \underset{(0.025,0.046)}{0.034} & 0 & 0 & 0 \\ \underset{(-0.018,0.015)}{-0.001} & \underset{(0.025,0.049)}{0.035} & 0 & 0 \\ \underset{(-0.129,0.014)}{-0.046} & \underset{(-0.193,-0.017)}{-0.078} & \underset{(0.023,0.129)}{0.060} & 0 \\ 0 & 0 & 0 & \underset{(0.089,0.161)}{0.119} \end{bmatrix}.$$

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