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Abstract

This paper proposes a simple model that possibly explains the productivity slowdown observed in Japan during the 1990s. Under a forbearance policy by the government toward nonperforming loans, one keeping insolvent firms afloat, other economic agents become exposed to a higher risk of not being paid by their customers (*payment uncertainty*). It is shown that the payment uncertainty, working through the market mechanism, causes an endogenous decline in the number of firms that are involved in the production of one good. Resulting disruptions of the division of labor among firms lower macroeconomic productivity. The relevance of this model to Japan's lost decade and other depression episodes, such as the Great Depression in the United States, is discussed.

JEL Classification: D24, E13, E32, E65.

Key words: Payment uncertainty, productivity, division of labor, Japan's lost decade, depression.

1 Introduction

This paper presents a simple theoretical model of the persistent slump in the productivity growth rate in the Japanese economy during the 1990s, during which time a huge amount of bad loans were rolled over under the government's (implicit) forbearance policy. Hayashi and Prescott (2002) show that the annual growth rate of total factor productivity (TFP) in the 1991–2000 period was 0.3% while that in the 1983–91 period was 3.7%, and stress that this sharp and persistent decline of TFP growth was the main cause of Japan's lost decade.[1]

In this paper I propose a theoretical model that may possibly explain the decline in productivity growth. The model focuses on the payment process in the economy, in which a firm buys an intermediate input, transforms it into the next-stage intermediate good, and sells it to another firm. The intermediate goods are passed down from firm to firm in the market and are finally transformed into consumer goods. On the one hand, I postulate an assumption, which seems fairly orthodox in economics (Smith [1776], Becker and Murphy [1992]) but does not generally receive much attention in recent macroeconomic literature, that productivity is enhanced by the division of labor. That is, the greater the number of firms that process an intermediate good is, the larger the number of the final consumer goods will be. On the other, I assume that banks' rollover of bad loans to firms makes a persistent "payment uncertainty," that there remains a positive probability that a firm will be made by banks to go bankrupt and will fail to pay its suppliers. An increase in the number of firms that process one intermediate good results in an increase in productivity, which enhances the profit of a firm, while it also causes a rise in payment uncertainty, which depresses the expected profit of the firm. Thus payment uncertainty causes an endogenous decline in productivity through firms'

[1]The TFP slowdown during the 1990s is confirmed by several authors. Jorgenson and Motohashi (2003) report that Japan's TFP growth was 1.01% in the 1975–90 period and 0.74% in the 1990–95 period. Miyagawa (2003) reports that TFP growth was 1.63% in the 1981–90 period and 0.84% in the 1991–99 period. The differences seem mainly due to differences in the definitions of capital inputs and the TFP factor.

decision making over the division of labor.

Since the rollover of bad loans was widespread in Japan after the bursting of asset-price bubbles in the early 1990s, the above argument gives a possible explanation for the sudden decline of TFP growth in the 1990s. Figure 1 shows the liabilities of failed firms in the Japanese economy. After the asset-price bubbles burst, the level of liabilities rose to about 10 trillion yen on the average in the 1990s from about 3 trillion yen in the 1980s. This increase in bankruptcies indicates that economic agents began to feel more risk of not being paid by their customers in the 1990s.

Figure 1. Total liabilities of failed businesses

The decrease in checks and bills clearing and fund transfers through the interbank computernetwork (Zengin system) in the 1990s may also indicate the rise of payment uncertainty. Figure 2 shows that payment activities in Japan have continued to shrink since the beginning of the 1990s. It is also said that Japanese firms came to prefer payment by cash and became less willing to accept promissory notes from customers or provide them credit. This change in payment activities strongly indicates a rise of payment uncertainty for Japanese firms.

Figure 2. Checks and bills clearing and fund transfer

Such circumstantial evidence of a rise of payment uncertainty may be said to support the plausibility of the scenario in this paper.

The organization of the paper is as follows. In the next section, I present the basic structure of the model. Section 3 describes the endogenous decline of productivity under the forbearance policy of the government and the rollover of bad loans by banks. Section 4 discusses the relationship of the present paper to the existing literature, and it provides some concluding remarks.

2 Basic model

The economy is comprised of consumers, firms, banks, and a government. In this economy, time is discrete and continues from zero to infinity: $t = 0, 1, 2, \cdots, \infty$. There are

infinitely many consumers who have identical consumption preferences and maximize

$$\sum_{t=1}^{\infty} \beta u(c_t), \tag{1}$$

where β $(0 < \beta < 1)$ is a discount factor, $u(c)$ is an increasing and concave function, and c_t is the consumption at date t. The measure of the consumers is normalized to one. There are also infinitely many firms with measure one, who are risk-neutral and maximize profits. Only firms, not consumers or banks, have access to the production technology described below.

There are infinitely many banks whose measure is also normalized to one. The main function of banks in this economy is to provide the medium of exchange: deposit money. Banks provide deposit money by discounting promissory notes (see "Payment process" subsection below for details). I make the assumption that the bank's measure is 1 in R^1, while the measure of consumers and firms is 1 in R^2. This assumption is made in order to insulate banks from the payment uncertainty introduced in Section 3, since under this assumption one bank can discount promissory notes from infinitely many firms at one date so that the law of large numbers guarantees that a bank's income is deterministically equal to the expected amount of payments on the promissory notes.

Production technology Consumers are endowed with a nondepletable asset (land), the total supply of which is K, at the initial date 0. At each date t, a firm can produce $A(n)$ units of good-n from one unit of land, where $n \in \{0, 1, 2, \cdots, \overline{n}\}$, and $A(n)$ is increasing and concave in n. The firm chooses the number n in order to maximize its profit (as expressed in equation (3) below). A firm can also transform one unit of the intermediate good-i $(i = 1, 2, \cdots, n)$ into one unit of the intermediate good-$(i-1)$. Only good-0 can be consumed by consumers (good-0 is the consumer good). There are two technology constraints for firms' production activity: (1) A firm that produced good-i cannot process its own output; another firm must purchase the output from the firm and transform it into good-$(i-1)$; (2) A firm can conduct production activities (to produce the initial intermediate good [good-n] from land, and to transform good-i into good-$(i-1)$, where $i = 1, 2, \cdots, n$) for $\overline{n} + 1$ times in a single period from date t to date $t + 1$. (I call

the period from date t to date $t+1$ *period* $t+1$ in what follows.) The second assumption guarantees that if firms produce good-n ($\leq \overline{n}$) from land at date t, it can be transformed into good-0 in the single period and can be consumed at date $t+1$. In other words, in a symmetric equilibrium where all firms choose the same n when they produce the initial goods from land, a firm conducts the processing of different intermediate goods for $n+1$ times during a single period between dates t and $t+1$. I assume that the consumer good that is produced during period $t+1$ cannot be stored or invested for the next period and must be consumed at date $t+1$. Otherwise it perishes at date $t+1$.

Payment process Firms possess only production technology, not money. But I assume that they can issue promissory notes when they rent land or purchase goods. The key point of the model is that the final settlement of the promissory notes may have some uncertainty when bad loans are being rolled over (see Section 3). There are two kinds of transaction that a firm undertakes in period $t+1$. First, a firm rents land from a consumer to produce good-n. The firm issues a promissory note and gives it to the consumer as payment for the rent. Second, a firm buys intermediate goods (good-i) from another firm to produce good-$(i-1)$. In this case too, the buyer issues a promissory note to the seller as payment. At date $t+1$, the consumer good (good-0) is produced, and consumers buy good-0 by issuing promissory notes to firms. These promissory notes issued by firms and consumers in period $t+1$ are discounted by banks at date $t+1$: banks give deposit money to the holders of promissory notes in exchange for the notes. I assume that banks randomly discount the promissory notes from firms and consumers.

Assumption 1 *Firms and consumers randomly choose banks to go to for discounting the promissory notes of their customers.*

After receiving deposit money, firms and consumers redeem their own promissory notes by paying deposit money to the holders (banks) of the notes.

Equilibrium In the competitive equilibrium, consumers, firms, and banks solve their optimization problems under the above technological and payment environment, given

prices of goods and land. The problem for the representative consumer is

$$\max_{c_t,k_t} \sum_{t=1}^{\infty} \beta^t u(c_t)$$

subject to

$$P_t c_t + Q_t k_t \leq R_t k_{t-1} + Q_t k_{t-1}, \tag{2}$$

and $k_0 = K$, where c_t is the consumption at date t, k_t is the land holding at date t, P_t is the price of the consumer good, Q_t is the price of land, R_t is the rent during period t.

The profit maximization problem for the representative firm when it buys good-i and produces and sells good-$(i-1)$ during period t is

$$\max_{y} P_{i-1t} y - P_{it} y,$$

where y is the amount of input and output and P_{it} is the price of good-i during period t. In the equilibrium where there is no uncertainty, it is obvious that $P_{it} = P_{i-1t}$ for $i = 1, 2, \cdots, n$. Note that $P_{0t} = P_t$ and P_t is the price of the consumer good at date t, which is the end of period t.

The profit maximization problem for the representative firm when it rents land from a consumer and produces and sells good-n during period t is

$$\max_{k,n} P_{nt} A(n) k - R_t k, \tag{3}$$

where k is the land rented and n ($n \in \{0, 1, 2, \cdots, \overline{n}\}$) is the kind of goods that the firm produces. Since $P_{nt} = P_t$ in the equilibrium where there is no uncertainty, firms choose n to maximize $A(n)$ in the equilibrium: $n = \overline{n}$. The competition among firms implies that in the equilibrium, $R_t = P_t A(\overline{n})$.

The banks' problem in this economy is to decide the rate of exchange between a promissory note issued as a payment for good-i and deposit money. In the equilibrium where there is no uncertainty, the competitive rate of exchange is one for one. Note that in the equilibrium, the nominal amount of assets (and liabilities) of one firm at the time of settlement is

$$A(\overline{n}) \sum_{i=0}^{\overline{n}} P_{it} = (\overline{n} + 1) A(\overline{n}) P_t.$$

This is because a firm piles up credits (and debts) as it sells (and buys) goods for $\overline{n}+1$ times.

Since land is a nondepletable asset and good-0 is a perishable good, the equilibrium allocation is simply as follows: Land holdings of the consumer at date t is $k_t = K$, and consumption at date t is $c_t = A(\overline{n})K$. The first order conditions (FOCs) for the consumer's problem imply that the real price of land ($q_t \equiv \frac{Q_t}{P_t}$) is determined by $q_t = \beta\frac{u'(c_{t+1})}{u'(c_t)}(\frac{R_{t+1}}{P_{t+1}} + q_{t+1}) = \beta(A(\overline{n}) + q_{t+1}) = \frac{\beta}{1-\beta}A(\overline{n})$.

Therefore, in the competitive equilibrium without (payment) uncertainty, firms choose the most productive business projects (i.e., $\overline{n}$), and macroeconomic productivity becomes highest ($A(\overline{n})$).

3 Payment uncertainty

In order to explain the productivity slowdown of the Japanese economy in the 1990s by this model, I assume that there emerge nonperforming loans from banks to a portion of firms with measure z ($0 < z < 1$) at date 0. I call these firms *zombie* firms.

Assumption 2 *A zombie firm owes a nonperforming loan to only one bank. The nonperforming loan to the zombie firm is observable only to the firm itself and the creditor bank. A zombie firm has the same production technology as other firms; therefore, consumers, other firms, or other banks cannot distinguish it from a healthy firm.*

Note that a zombie firm is not inefficient *per se* in terms of production technology; the only difference is that the bank has too large claim on the (prospective) assets of the zombie firm. The reason why nonperforming loans are generated is not specified in this paper. I simply assume that some exogenous shock (e.g., the emergence and bursting of asset-price bubbles) made some firms overly indebted. I assume that the nominal amount of the nonperforming loans to each zombie firm at date 1 (N_1) is very large (see the next "Bankruptcies" subsection).

A zombie firm has no asset corresponding to the liability N_1. A bank has the nonperforming loan N_1 to z firms as its asset, while it has the corresponding liability $N_1 z$, which

is the bank deposits from consumers. Therefore, a consumer has the bank deposit ($N_1 z$) as his asset in addition to landholdings at date 1. Since the consumer's bank deposit $N_1 z$ is not backed by firms' assets, zombie firms would go bankrupt and the banking system would collapse immediately at date 1 unless the government guaranteed the deposits by (implicitly) committing to transfer future tax revenues to the depositors (consumers). I assume that the government does not want to have all zombie firms go bankrupt at once for political reasons and that it guarantees the deposits. In what follows, I describe the bankruptcy process and the forbearance policy adopted by the government, and then the equilibrium outcome under this policy.

Bankruptcies I assume that a bank holding the nonperforming loan to a zombie firm can choose whether or not to make the firm go bankrupt at settlement time. When the firm goes bankrupt, the creditor bank can seize all the assets of the firm, and all payments from the firm to other creditors are cancelled. To make clear the meaning of this assumption, let us consider the case where a zombie firm continues to operate and conducts production activities during period t. At date t, the settlement time, the firm has as its assets the deposit money that it received by discounting promissory notes issued by its customers, while it has as its liabilities the nonperforming loan N_t from its bank and the account payable to promissory notes that the firm issued during period t. If this firm goes bankrupt at date t, the creditor bank that holds N_t seizes all the deposit money and cancels payment on the promissory notes that the debtor firm issued. Since the promissory notes issued by the zombie firm were handed to its suppliers and were discounted by other banks (see Assumption 1), when the firm goes bankrupt, other banks incur losses by cancellation of the promissory notes. Caveats for this assumption on bankruptcy follow. One may consider that the assumption that the bank takes everything is too strong as a model of bankruptcy, since in the Japanese legal system, a bank's claim does not necessarily have priority over the claims by holders of the promissory notes issued by the bankrupt firm. But in practice, it usually happens that suppliers fail to collect on their claims. In this paper, I made the above extreme

assumption in order to focus on the uncertainty that suppliers feel when they sell goods to (possibly zombie) firms. Another caveat is that I implicitly assume that N_t is always larger than the amount of deposit money that the firm holds when it goes bankrupt. This assumption is just for simplicity of calculation. Otherwise the bank seizes only N_t if the assets of the firm exceed it, and holders of promissory notes get paid partially, making the analysis more complicated without making substantial changes in the results.

The forbearance policy For some political reason, the government wants not to make zombie firms go bankrupt all at once, but to make them go bankrupt slowly in a planned manner. The government chooses x, the rate of bankruptcy, where the ratio of x of the remaining zombie firms go bankrupt at each date. Therefore, the measure of zombie firms during period t (z_t) evolves by $z_1 = z$, and $z_{t+1} = (1-x)z_t$ for $t \geq 1$. I assume that the government cannot set x at zero, but there is a lower bound $\underline{x}(> 0)$ such that $\underline{x} \leq x < 1$. One reason for making the assumption that the government, not banks, sets the rate of bankruptcy of zombie firms is as follows. In the early 1990s in Japan, the government announced that the disposal of nonperforming loans (and the rehabilitation of debtors) was to be done gradually and methodically. Since the Ministry of Finance had strong control over banks' operations, it is quite likely that MOF actually determined the pace of disposal of nonperforming loans until the policy regime drastically changed during a financial crisis in the 1997–98 period. Therefore, the assumption that the government determines x is plausible as a formalization of Japan's forbearance policy toward the nonperforming loans of the 1990s.

In order to simplify the calculation, I assume that at date t, bankrupt firms of measure xz_t are replaced by newly established firms of the same number, and thus the total measure of the firms remains constant as one. The government also chooses lump-sum tax T_t on consumers, which is to be transferred to banks in order to compensate them for the losses of bankruptcies. The amount of the tax is specified later in equation (8).

Firms' problem If zombie firms of measure xz_t go bankrupt at date t, there emerges a risk that a promissory note will not be settled by the payment of deposit money. Since

Assumption 2 implies that a seller cannot tell whether the buyer is a zombie firm or not, sellers become constantly exposed to a positive probability of not being paid. Therefore, prices of intermediate goods are distorted by this payment uncertainty. Consider a (healthy) firm that produces and sells good-$(i-1)$ in period t. Since the buyer will go bankrupt and fail to pay at date t with probability xz_t, the expected profit of the firm is $(1-xz_t)P_{i-1t}y - P_{it}y$, where $i = 2, \cdots, n$, and y is the amount of input and output. And since consumers do not go bankrupt, the profit of the firm that sells good-0 to consumers is $P_{0t}y - P_{1t}y$. Therefore, in the equilibrium where the profit-maximizing firms earn zero profits, prices of intermediate goods are determined by

$$P_{it} = (1-xz_t)^{i-1}P_t, \quad i = 1, 2, \cdots, n. \tag{4}$$

Since firms rent land from consumers, they choose n to maximize the expected profit: $(1-xz_t)P_{nt}A(n)k - R_tk = \{(1-xz_t)^nA(n)P_t - R_t\}k$, given P_t and R_t. Thus under payment uncertainty, firms choose n_t such that $n_t = \min\{n_t^*, \overline{n}\}$, where

$$n_t^* = \arg\max_n (1-xz_t)^nA(n). \tag{5}$$

In the equilibrium, the rent of land becomes

$$R_t = (1-xz_t)^{n_t}A(n_t)P_t. \tag{6}$$

Note that since there is no real disruption of the production process, the final output of good-0 is $A(n_t)$ even under payment uncertainty, and thus consumption is

$$c_t = A(n_t)K \tag{7}$$

in the equilibrium. A consumer obtains the expected dividend from land of $(1-xz_t)R_t$, since a firm fails to pay R_t with probability xz_t. Note that the difference between P_tc_t and $(1-xz_t)R_tK$ is absorbed in the banking sector through bankruptcies of zombie firms (see the following "Banks' problem" subsection). Note also that the promissory note issued during period t at face value of P_{it} is discounted by banks at the price of $(1-xz_t)P_{it}$. Thus firms or consumers who received a promissory note P_{it} obtain $(1-xz_t)P_{it}$ units of deposit money by discounting the note.

Banks' problem Under the forbearance policy, banks play two roles in the economy: they discount promissory notes; and they roll over the nonperforming loans to $(1-x)z_t$ zombie firms and make xz_t zombie firms go bankrupt at date t, receiving a lump-sum transfer T_t from the government as a compensation for losses. For discounting the promissory notes in equilibrium, banks give $(1-xz_t)P_{it}$ units of deposit money to the holder of the promissory notes with a face value of P_{it}, since the issuer goes bankrupt and fails to pay with probability xz_t. Since I assumed that the measure of banks is one in R^1 and the measure of firms (and consumers) is one in R^2, banks discount infinitely many promissory notes at each date t, and they get paid deterministically an amount identical to the expected value. For rolling over the nonperforming loans and corresponding deposits, banks offer the nominal market rate of interest.[2] Denoting the nominal market rate of interest during period t by I_t, which is determined in the equilibrium by the FOC (11) for the consumer's problem below, we find that unbacked bank deposits D_{t-1} must increase to $(1+I_t)D_{t-1}$ at date t, since otherwise consumers would run on banks to withdraw D_{t-1} and invest money in other assets (land). If a zombie firm does not go bankrupt, the nonperforming loan to the firm evolves by $N_t = (1+I_t)N_{t-1}$. If a zombie firm goes bankrupt, the bank seizes the remaining assets: $A(n_t)k_t\{P_{0t}+\sum_{i=1}^{n_t}(1-xz_t)P_{it}\} = A(n_t)k_tP_t\sum_{i=0}^{n_t}(1-xz_t)^i = \frac{1}{xz_t}A(n_t)k_tP_t\{1-(1-xz_t)^{n+1}\}$, where k_t is land rented by one firm. Thus the bank seizes assets of $A(n_t)k_tP_t\{1-(1-xz_t)^{n+1}\}$ by making xz_t firms go bankrupt at date t. This amount is exactly equal to the difference between P_tc_t and $(1-xz_t)R_tK$ in the equilibrium where $k_t = K$. The gap between N_txz_t and $A(n_t)k_tP_t\{1-(1-xz_t)^{n+1}\}$ must be filled by a transfer from the government. Therefore, the government must set the lump-sum transfer at

$$T_t = N_txz_t - A(n_t)k_tP_t\{1-(1-xz_t)^{n_t+1}\}, \tag{8}$$

[2]As long as the government guarantees deposits, banks can offer a higher rate than the market rate for the unbacked deposits and the nonperforming loans. Since the higher growth of bank deposits and nonperforming loans does not change the probability of not being paid (xz_t) that faces firms and consumers, the higher rate does not change the results of this analysis qualitatively. Therefore, for simplicity, I assume that banks offer the lowest rate for deposits and nonperforming loans.

in order to let banks make xz_t of their zombie firms go bankrupt at date t. The total amount of nonperforming loans during period $t+1$ is $N_t z_{t+1}$, which equals the total unbacked deposits (see the next subsection).

Consumers' problem The consumers' problem under the forbearance policy is as follows:

$$\max_{c_t, k_t, D_t} \sum_{t=1}^{\infty} \beta^t u(c_t)$$

subject to

$$P_t c_t + Q_t k_t + D_t \leq (1 - xz_t) R_t k_{t-1} + Q_t k_{t-1} + (1 + I_t) D_{t-1} - T_t, \tag{9}$$

given prices (P_t, Q_t), the lump-sum tax (T_t), and the initial values $k_0 = K$ and $(1 + I_1)D_0 = N_1 z$, where D_t is the bank deposit at date t. I assumed for simplicity that consumers obtain $(1 - xz_t)R_t k_{t-1}$ deterministically as a dividend from land k_{t-1} by, say, forming fair insurance among themselves. As equation (7) shows, the equilibrium allocations are $k_t = K$ and $c_t = A(n_t)K$. The real asset price $q_t = \frac{Q_t}{P_t}$ is determined by

$$q_t = \frac{\beta u'(c_{t+1})}{u'(c_t)} \{A(n_{t+1})(1 - xz_{t+1})^{n_{t+1}} + q_{t+1}\}. \tag{10}$$

The market rate of interest is determined by

$$1 + I_t = \frac{u'(c_{t-1})}{\beta u'(c_t)} \frac{P_t}{P_{t-1}}. \tag{11}$$

The equilibrium allocations, the budget constraint, (6), (8), $N_t = (1 + I_t)N_{t-1}$, and $(1 + I_1)D_0 = N_1$ imply that $D_t = N_t z_{t+1}$.

Welfare implications Let us define an integer $t(x)$ by $n_t < \overline{n}$ for $t \leq t(x)$ and $n_t = \overline{n}$ for $t > t(x)$. As long as x is not too small, $t(x)$ is decreasing in x. If $x = 1$, $A(n_1)$ declines sharply but is restored immediately, i.e., $A(n_t) = A(\overline{n})$ for $t \geq 2$. Since consumption is proportional to productivity, the utility of consumers (equation [1]) may become smaller if productivity is less than $A(\overline{n})$ for longer periods. Thus if the government sets x at a smaller value, social welfare may become smaller too. In Figure 3, social welfare $\sum_{t=1}^{\infty} \beta^t u(c_t)$ is plotted as a function of x, given that $u(c) = \ln c$ and $A(n) = n^{\alpha}$. The

parameter values are $\alpha = 0.2$, $\beta = 0.99$, $K = 1$, $z = 0.2$, $\overline{n} = 1000$, and $\underline{x} = 0.01$. The paths of productivity and the real land price for a small x and a large x are also shown in the figure.

Figure 3. Welfare, productivity, and land prices

In the region of $0.016 < x < 1$, welfare is increasing in x, implying that immediate bankruptcies of zombie firms bring about the highest welfare for consumers. The figure shows that productivity (or consumption) and land price recover rapidly if the zombie firms go bankrupt quickly and stagnate for a longer period if the zombie firms are kept afloat longer. Suppose that the government has some political reason to lower x, and that it mistakenly regards productivity $\{A(n_t)\}_{t=1}^{\infty}$ to be an exogenous process that is independent of x. In this case, a benevolent government, wanting simply to maximize social welfare, may set x at such a small value that it unintentionally causes productivity to stagnate.

Equation (10) shows that land prices may also stagnate, mainly for two reasons. One reason is the stagnation of productivity, and the other is that some of the dividends from land $(A(n_t)\{1-(1-xz_t)^{n_t}\})$ are seized by banks through bankruptcies of zombie firms. This second reason implies that the land price q_t is still less than $A(\overline{n})\frac{\beta}{1-\beta}$ even at $t > t(x)$ when $n_t = \overline{n}$. Although it is not evident visually, Figure 3 shows that the land price for $x = 0.1$ is lower than that for $x = 0.9$ even at $\forall t > t(0.1)$.

4 Literature and concluding remarks

The mechanism of the productivity slowdown described in Section 3 implies that investments are not necessarily constrained by, say, a lack of liquidity. Hayashi and Prescott (2002) claim that a credit crunch or other problems in financial intermediation may not be the culprit behind Japan's decade-long recession, because they find that Japanese corporations were able to find financing for investments in the 1990s.[3] The mechanism

[3]Hosono and Watanabe (2002) also confirm empirically that the liquidity constraint for Japanese firms did not become severer in the 1990s. Andolfatto (2003) also argues that monetary and financial problems in Japan's lost decade may be irrelevant to the output decline.

in the present paper is consistent with their view that productivity slowed down even though investments were not constrained.

The literature on the Great Depression in the United States during the 1930s also shows that a main cause of the severe output decline was a productivity fall, and that financial constraints on investments were insignificant (see, for example, Chari, Kehoe, and McGrattan [2002]). Ohanian (2001) points out that a large part of the TFP decline is not explained by such usual causes as changes in capacity utilization or input quality, and he conjectures that declines in organization capital may be the explanation. Disruption of the division of labor due to payment uncertainty can be one potential mechanism for declines in organization capital. The fact reported by Anari et al. (2003) that the liquidation process of failed banks usually took three or more years indicates that there might have been persistent payment uncertainty in the 1930s. Thus the model in the present paper may be consistent with Ohanian's view, and relevant to the productivity fall during the Great Depression.

The story in this paper can also explain the sharp contrast between TFP growth in Chile and Mexico after the debt crisis in the early 1980s. Bergoeing et al. (2002) show that productivity growth was faster in Chile than in Mexico, and they hypothesize that Chile's earlier policy reforms in banking and bankruptcy procedures generated this difference. The paths of the productivity growth for a large and a small x in Figure 3 replicate the patterns of recovery in Chile and Mexico, respectively.[4]

The decline in productivity in this paper is ultimately driven by the disruption of the division of labor among firms. This mechanism is similar to Blanchard and Kremer (1997) and Kobayashi (2004). The novelty of the present paper is that the endogenous disruption of the division of labor occurs through the price mechanism in the market, in which firms

[4]Bergoeing et al. (2002) provide the explanation for the growth difference that before policy reform, the government favors one sector by allocating larger resources to it. This explanation implies that the government intentionally lowers productivity in order to give favors to a specific sector, meaning that the government is not maximizing social welfare as a whole. The theory in the present paper implies that even a welfare-maximizing government may cause persistent stagnation of productivity if it mistakenly believes that productivity is exogenous to its policy toward the bankruptcy rate (x).

trade intermediate goods as anonymous sellers or buyers. The other papers assume that firms form a *team* for production explicitly, and the results in these papers may therefore crucially depend on the specific assumptions on relationships among firms in a team. The results in the present paper do not depend on any strategic relationships among firms, and thus they hold under more general environments. In order to check disruption of the division of labor, Kobayashi and Inaba (2004) conducted an empirical analysis using the Input-Output Tables. We found that output declined more in industries with a more complex input-output structure in the early 1990s in Japan, and that the output decline was more severe in industries with heavier debts.

Payment uncertainty associated with promissory notes (or trade credits) plays a central role in the disruption of the division of labor in this model. Kiyotaki and Moore (1997) and Calvo (2000) address the problem of trade credits, and they propose theoretical models in which a disruption of a chain of trade credits amplifies a recession. The basic structure of their models is that a liquidity shortage is amplified through disruption of the chain of credits, and it seems to explain a sharp and temporary recession associated with a liquidity crisis or a credit crunch, although not a decade-long slowdown of productivity growth of the kind observed in Japan. In my model, persistent payment uncertainty, not actual disruption of credit chains, causes shrinkage of the division of labor. Since the risk of not being paid persists because of the forbearance policy, and actual disruptions of credit chains seem short-lived, the model in this paper may better explain Japan's lost decade.

In this model, payment uncertainty, i.e., a risk of not being paid, is faced by new creditors and suppliers, not by incumbent banks that roll over bad loans to zombie firms. Lamont (1995) argues that investments and outputs may inefficiently shrink if new creditors have a risk of not being paid in full because incumbent creditors take most of the outputs. Although the Lamont model shares the thinking of my model in some respects, it does not show a decrease in productivity, while it does show that a decrease in investments can be caused by a demand shortage in an economy of monopolistic competition.

The productivity slowdown in Japan's lost decade is and will continue to be a big puzzle. In this model, I presented a possible mechanism of productivity decline, which is that the government's forbearance policy kept nonviable zombie firms afloat and raised payment uncertainty for other firms. This causes endogenous lowering of the level of the division of labor and thus of aggregate productivity.[5] I hope that the mechanism presented in this paper may shed some light on this challenging puzzle. Although empirical findings by Kobayashi and Inaba (2004) provide circumstantial support for the idea that the TFP slowdown in Japan has been caused by disruption of the division of labor, which may also be called declines in organization capital (Ohanian [2001]), empirical examination on whether the productivity slowdown was actually caused by payment uncertainty is a topic for future research.

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[5] A disruption of the division of labor due to payment uncertainty may also explain TFP declines in ordinary recessions, since it usually takes some time for nonviable firms to go bankrupt, and they raise payment uncertainty until they stop operating.

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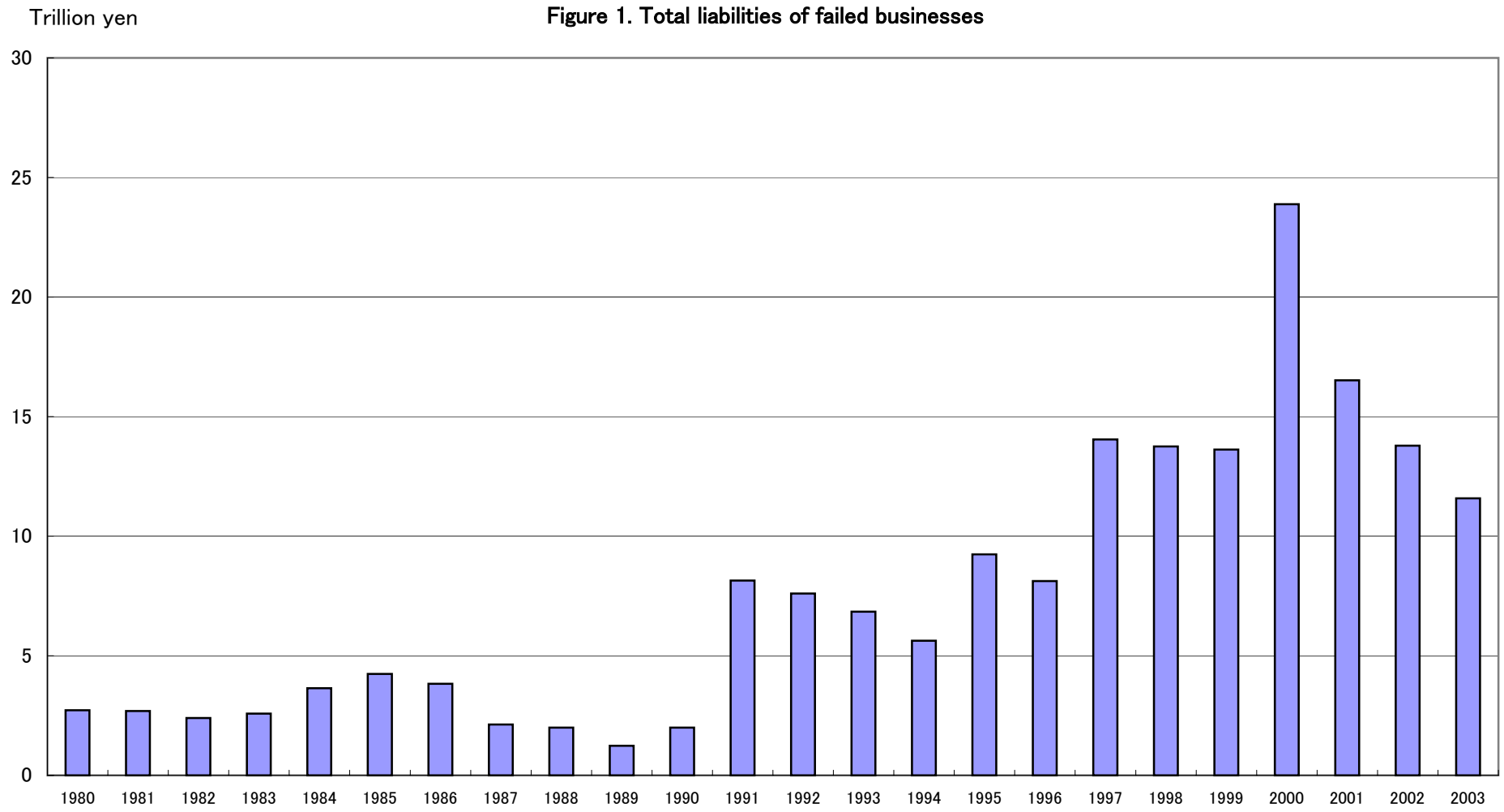
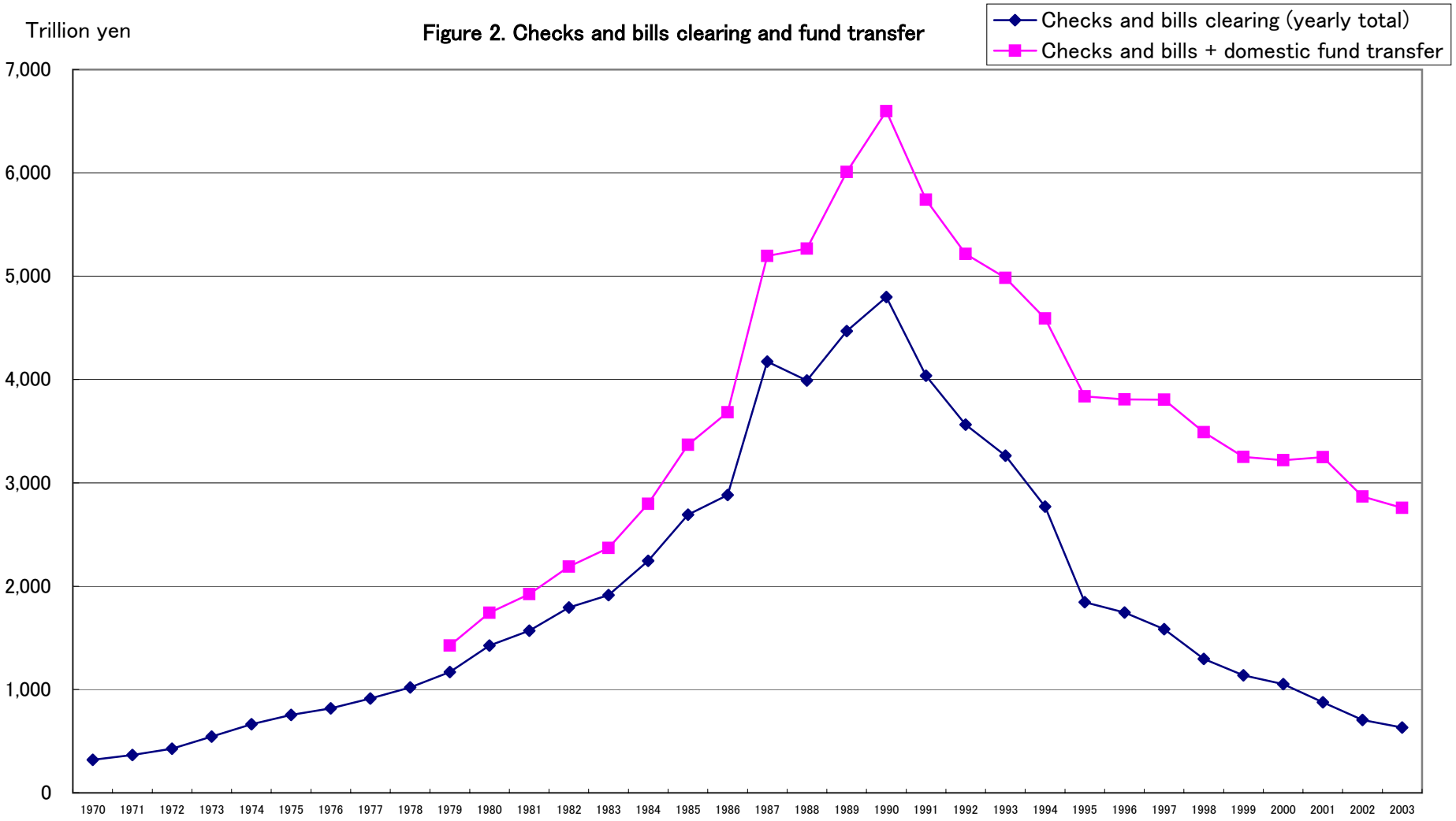
Figure 1. Total liabilities of failed businesses



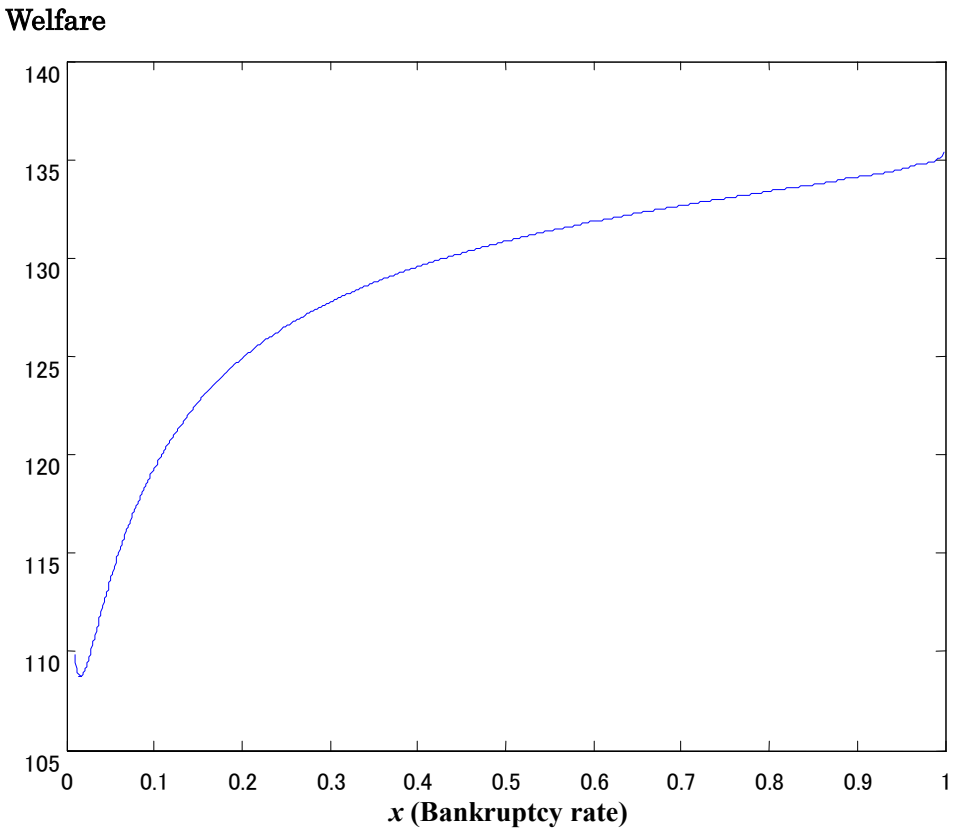
Source: Tokyo Shoko Reserch.
Note: Summary of major business failures with more than 10 million in liabilities.

Figure 2. Checks and bills clearing and fund transfer



Source: Tokyo Bankers Association.

Figure 3. Welfare, productivity, and land prices



Parameters: $z = 0.2$, $\alpha = 0.2$, $\beta = 0.99$, $K = 1$, $\underline{x}$=0.01, $\bar{n}$=1000