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Abstract

This paper aims to analyze and discuss the relationship between business cycles and bankruptcy reforms. In the first part of this paper, we use a two specie-population dynamic system to study the dynamics of debt and capital. Then, the techniques of biological control are adapted for the stabilization of credit cycles and we attempt to bring the system to a steady state in the uncontrolled system, with the minimum cost of policy intervention and in minimum time. For this purpose, bang-bang control is one solution; it suggests that a seemingly abrupt and surprisingly rapid change in legal rules, for example bankruptcy reforms, can be justified in this respect. In the second part of the paper, some examples from the U.S. and Japanese bankruptcy legislations are taken to evaluate the actual bankruptcy reforms.

1 Introduction

Bankruptcy legislations and their subsequent revisions have been promoted by major recessions in history. The United States in the 1930s and Japan in the 1990s are notable examples. The main purpose of this paper is to discuss the desirability of such legislations as an economic policy. Since bankruptcy laws deal with the problems of debt reduction, we pay special attention to the problem of credit (debt) expansions and contractions in business cycles. For this, a model

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of "credit cycles," which shares the intention of Kiyotaki and Morre (1997) but differs fundamentally with respect to the tools. Kiyotaki and Moore's (hereafter KM) credit cycle model is perhaps one of the most well-known theories explaining asset bubbles and the subsequent bad loan problems. Though their model is based on the incomplete contract theory on the microfoundation level, the most salient feature of the analysis is the dynamic interaction between investment and debt level, which they claim is similar to predator-prey dynamics. There is a growing body of literature that follows their analysis, such as Paasche (2001) and Krishnamurthy (2003).

Another strand of literature related to this paper is macroeconomic analysis of the U.S. bankruptcy reforms, which have been debated on since the 1990s. There are numerous researches, such as Athrena (2002), Li and Sarte (2002), and Zha(2001) that reflect such heated political debates. These studies are based on the dynamic general equilibrium model supported by numerical simulations in order to evaluate concrete rules such as those requiring means-testing before filing or lower asset exemptions.

Unlike KM's credit cycle model and the macroeconomic analysis of the U.S. bankruptcy reforms, which began in the 1990s, this paper is a direct application of population dynamics. The justification for our approach is policy oriented. KM indicated some interesting features of the nonlinear dynamics of debt and investment, which is similar to (yet different from) predator-prey dynamics. This kind of cyclical behavior has not been analyzed in the literature on the macroeconomic analysis of bankruptcy reforms. Bankruptcy reforms as optimal feedback controls for business cycles based on the general equilibrium model are topics for future research. The task in this paper is simple: If we introduce an elementary model and apply the control techniques of mathematical biology to the problem of bankruptcy reforms, what kind of policy objectives should be set, and what could be the policy implication of the solution? The policy objective of the macroeconomics of bankruptcy reforms is (following the standard criterion of general equilibrium analysis) to maximize the present value of the utility function of representative households. However, if we apply the control problem of population dynamics to the cycles of debt and capital, the policy objective becomes, say, to stabilize the system with minimum policy cost and in minimum time. This perspective, although rarely found in such topics,[1] deserves attention. As we see later in many cases, bankruptcy reforms were introduced during the recessions, when both creditors and debtors may have been facing an adverse situation. Therefore, the introduction and enforcement of a drastic change in the credit contract often encounters stubborn resistance. The policy cost is not negligible and we think it may be a legitimate choice it as one of

[1] The tool of population dynamics is familiar to environmental economics. Further, in this field, the policy objectives of environmental economics is to maximize the present value of, say, net revenues from harvesting (see Conrad and Clark (1987)).

the performance indexes of the control problems. Minimizing the time taken to stabilize the economic system is also important because with the passage of time, structural changes in the system may be inevitable, and a policy that was initially appropriate may become harmful to the system after the transition. It is a shortcoming of our discussion that the desirability of the steady state after stabilization is not dealt with explicitly. Our control problem and the standard general equilibrium analysis should be incorporated in future studies.

This paper consists of two parts. In the first part, we use a two specie-population dynamic system to study the dynamics of debt and capital from the outset. Next, we follow the techniques of optimal biological control as presented in Goh, Leitmann and Vincent (1974) and Hirata (1980), who generalized the results of Goh et al to the wide classes of population dynamics including symbiosis, competition, and predator-prey. The purpose of these researches is to stabilize the population of the species with minimum cost to the environment (particularly finding the optimal way to use pesticide). Similarly, the purpose of this paper is to stabilize the credit cycles and bring the system to the steady state of the uncontrolled system with minimum cost of policy intervention and in minimum time. For this purpose, we claim bang-bang control as one solution and suggest that seemingly abrupt and surprisingly rapid changes in legal rules, say bankruptcy reforms, can be justifiable in this respect. In the second part of the paper, we take some examples from the U.S. and Japanese bankruptcy reforms. We present certain historical events of major bankruptcy reforms as examples of responses to the business cycles. In the concluding remarks, we evaluate the desirability of such reforms.

2 The Model

This section attempts to apply a simple biological model so as to focus on the features of the dynamic interaction between debt and capital. The economy can be in either of two states — boom or recession. Alternatively, there are two sectors which experience either a boom or a recession. First, we identify the situation when the credit cycles (predator-prey dynamics of debt and capital) occur. Next, we concentrate on the cases in which the system exhibits these cycles (we refer to them as "credit cycles") and attempt to introduce controls into the system.

2.1 Credit Cycles as Predator-Prey Dynamics

Consider a continuous-time economy with two goods, capital K and a commodity. Capital includes any means of production (of the commodity) like land, factories, inventories, good-will, and so on. There are two active agents in the economy — firms and banks. The firms produce the commodity using the capital that they possess. There is an inactive agent called "households" outside the system, which consumes only the commodity produced by the firms. We consider a situation where the commodity market always remains in equilibrium and the firms' supply determines the quantity of the commodity in the equilibrium as given, by Say's law. If the commodity is sold to the household, then the firm receives some units of capital in exchange. Thus, selling the commodity to the households increases the capital of the firms. The firms can also increase their capital through innovation. In either case, we assume that the firms that are not in debt can (and actually do) increase their capital logistically,

$$\frac{\dot{K}}{K} = e_1 - \lambda K, \tag{1}$$

where $e_1 > 0$ and $\lambda > 0$. This assumption relies on the logic that the innovation and the spread of new products grow rapidly at first and then slowly approaches a certain saturation level. [2]

Banks extend credit to the firms so that the latter can increase their capital to a greater extent than what they would have been able to increase without such assistance. The volume of the debt (credit) is denoted as B. We assume that banks cannot increase the credit (debt) advanced to firms unless a certain level of capital is already present with the firms. Such debt without capital decreases exponentially, satisfying the following expression:

$$\frac{\dot{B}}{B} = -e_2, \tag{2}$$

where $e_2 > 0$. The logic behind this assumption is literally "biological." Suppose a bank is collecting the debt extended to a certain firm. The bank has already liquidated all the capital that the firm formerly possessed, however there still remains a substantial amounts of debt to be repaid. Then, the manager or the owner of the firm attempts to repay the debt by lowering their standard of living, until the firm finally becomes defunct. If there is nobody operating the firm or responsible for it, the debt must finally be discharged, i.e, become zero. Thus, equation (2) represents the rate at which the firms (or the persons who operate and/or own them) become defunct. It is not very unnatural to assume such a rate, which is expressed by equation (2).

We now introduce the interaction between debt and capital. Assume that a prudent regulation is imposed on the banks that the growth rate of debt should be proportional to the existing capital of the firm, which can be used as collateral for the debt. Now, suppose that there are two states of the entire economy(or that there are two kinds of sectors or firms). The first is "symbiosis," where the growth rate of capital increases with the volume of the debt and the growth rate of debt is increases with the volume of the capital. This state corresponds to a

[2] Yoshikawa (2003) proposes a model with the logistic growth of the aggregate demand.

boom in the economy. The second state is "competition," where the growth rate of capital is decreases with the volume of the debt and the growth rate of debt is decreases with the volume of the capital. This state corresponds to a recession in the economy.

Therefore, in the state of symbiosis,

$$\frac{\dot{K}}{K} = aB, \quad \frac{\dot{B}}{B} = bK,$$

where $a > 0$ and $b > 0$. The coefficient a represents the rate at which the debt enhances capital accumulation. The coefficient b represents the imposition of a prudent regulation, governing lending by banks. Combining with (1) and (2), the symbiosis system can be written as

$$\frac{\dot{K}}{K} = e_1 - \lambda K + aB, \tag{3}$$

$$\frac{\dot{B}}{B} = -e_2 + bK. \tag{4}$$

In this state, both the capital and debt increase, and the growth in one increases the growth in the other. On the other hand, if the economy is in the state of competition, [3]

$$\frac{\dot{K}}{K} = -cB, \quad \frac{\dot{B}}{B} = -dK,$$

where $c > 0$ and $d > 0$. The coefficient $-c$ represents the rate at which the debt reduces the capital by liquidation. This rate is negative in a competition system because the default in repayment by firms results in their liquidation. Hence, a higher debt level implies greater piece-meal liquidation, in which only scrap value of the capital is retained.[4] The coefficient $-d$ represents imposition of the prudent regulation, that specifies the level at which liquidation should occur. The reason the coefficient is negative is that all firms default in this state and the prudent regulation must ensure the reduction of the debt. Again, combining with (1) and (2), we get

$$\frac{\dot{K}}{K} = e_1 - \lambda K - cB, \tag{5}$$

$$\frac{\dot{B}}{B} = -e_2 - dK. \tag{6}$$

[3] Here the word "competition" is used in the biological sense, and not in the economic sense. It implies that two variables, for example, are decreasing each other like the populations of two species fighting for the same prey.

[4] We do not consider the reorganization of the firm because of the myopia of banks. Alternatively, reorganization can be included in the symbiosis system.

In the competition system, both debt and capital decrease, with a decrease in one leading to a decrease in the other.

We now define the probability of recession p, which is a constant, as the probability at which the system switches to the state of competition, in which all firms ultimately default and are liquidated. Alternatively, p can be interpreted as the proportion of firms in the state of recession, and $1-p$ as the proportion of firms in the state of boom. Calculating the expected value of $\frac{\dot{K}}{K}$ and $\frac{\dot{B}}{B}$, the entire system can be expressed by

$$\frac{\dot{K}}{K} = e_1 - \lambda K + (a - (a+c)p)B \equiv F(K, B), \tag{7}$$

$$\frac{\dot{B}}{B} = -e_2 + (b - (b+d)p)K \equiv G(K, B). \tag{8}$$

To examine the property of the system, we check the sign pattern of the partial derivative of F and G. Because

$$\frac{\partial F}{\partial B} = a - (a+c)p,$$

$$\frac{\partial G}{\partial K} = b - (b+d)p,$$

we can claim the following:

Theorem 1 *(a) If*

$$a - (a+c)p > 0 \quad \textit{and} \quad b - (b+d)p > 0, \tag{9}$$

the system becomes that of symbiosis (the state of boom).

(b) If

$$a - (a+c)p < 0 \quad \textit{and} \quad b - (b+d)p < 0, \tag{10}$$

the system becomes that of competition (the state of recession).

(c) If

$$a - (a+c)p < 0 \quad \textit{and} \quad b - (b+d)p > 0 \tag{11}$$

or

$$a - (a+c)p > 0 \quad \textit{and} \quad b - (b+d)p < 0, \tag{12}$$

the system becomes that of predator-prey (exhibits credit cycles).

We now focus on part (c) of Theorem 1 to check the condition in which cycles occur. Condition (11) suggests a combination of a smaller a and a larger c, which implies that the capital accumulation effect of debt in the state of boom is relatively small and the capital reducing effect of debt in the state of recession is relatively large. This condition also suggests a combination of a larger b and a smaller d, which implies that the prudent regulation allows the creation of a relatively greater volume of debt in the state of boom and reduces the debt relatively slowly in the state of recession. Thus, the regulation is relatively lax in both states. Condition (12) suggests just the opposite — a combination of a larger a and a smaller c, smaller b and greater d — implying that the capital accumulation effect in the state of boom is large, the capital reducing effect in the state of recession is small, and the regulation is stringent in both the states. This combination of parameters is natural because condition (11) suggests that even the boom situation causes relatively less capital accumulation and the recession causes greater capital destruction, so the prudent regulation need not be very stringent in both the states. On the contrary, condition (12) suggests greater capital accumulation in the state of boom and less capital reduction in the state of recession, which justify the stringent regulation. From this point forward, to discuss these cycles in simple terms, we assume that only the condition (11) holds.

We now derive the steady state of the system. From (7) and (8), the steady state (K^*, B^*) is characterized by

$$K^* = \frac{e_2}{b - (b+d)p}, \tag{13}$$

$$B^* = \frac{\lambda e_2 - (b - (b+d)p)e_1}{(a - (a+c)p)(b - (b+d)p)}. \tag{14}$$

As we assumed in (11), $K^* > 0$. Further, if

$$\lambda e_2 - (b - (b+d)p)e_1 < 0, \tag{15}$$

$B^* > 0$ also holds. In the following subsection, we attempt to discuss the steady state in which $K^* > 0$ and $B^* > 0$; hence, we further assume that condition (15) also holds. This assumption can be interpreted as a smaller value of λ and e_2, and a greater value of e_1. That is, the logistical growth rate of capital (without debt) is relatively large and the diminishing rate of debt (without capital) is relatively small.

2.2 Controlling Credit Cycles using Bankruptcy Reforms

Next, we consider the problem of stabilizing the system comprising credit cycles by reducing the volume of debt and minimizing the cost of policy interventions in minimum time. Let the rate of reduction of the debt be $u(t)$. The system subject to this control variable is expressed as

$$\begin{aligned} \frac{\dot{K}}{K} &= F(K,B), \\ \frac{\dot{B}}{B} &= G(K,B) - f(t)u(t), \end{aligned} \tag{16}$$

where $f(t)$ indicates the effect of the debt reduction policy. Hence, $f(t)u(t)$ is the rate of the total volume of the reduced debt.

We assume the following: $u(t)$ is a piecewise differentiable admissible control and satisfies the constraint

$$0 \leq u(t) \leq u_{max}, \tag{17}$$

where u_{max} is a constant defined by legal rules other than the bankruptcy code or the upper limit the congress, the government, the court, or the society regard as legitimate.

$f(t)$ is continuous and its derivative is $\dot{f}(t)$. It satisfies the constraint

$$0 < f(t) < \infty, \quad \dot{f}(t) < 0. \tag{18}$$

$\dot{f}(t) < 0$ implies that the effect of debt reduction diminishes as time goes by.

Let the initial and terminal conditions be

$$\begin{aligned} K(t_0) &= K_0, \quad B(t_0) = B_0, \\ K(t_f) &= K^*, \quad B(t_f) = B^*, \end{aligned}$$

where K_0 and B_0 are positive constants, and keeping in mind the assumptions (11) and (15) in the previous subsection, K^* and B^* are also positive constants. t_0 and t_f are the times of start and completion of the program, respectively. We leave t_f unspecified.

Since our purpose is to stabilize the system with the least cost of policy intervention and in minimum time, let the performance index be

$$J = \int_{t_0}^{t_f} (u+1)dt. \tag{19}$$

We assume that the cost of policy intervention is increasing linearly with the control u and, for simplicity, we assume the coefficient to be 1. Since 1 appears in the second term in the integral, J indicates the cost index of policy intervention and the time spent to stabilize the economy. The control problem is to find an admissible control function, $u(t)$, that drives the system from the observed state (K_0, B_0) to (K^*, B^*) such that J is minimized subject to the constraints (17) and (18), where the system equations with the control variable satisfy (16).

The Hamiltonian function for this problem is given by

$$H(K, B, u, \mu) = \mu_0(u+1) + \mu_1 KF(K, B) + \mu_2[BG(K, B) - ufB]. \tag{20}$$

For optimal control $u = u^*(t)$ and trajectory $K = K^*(t),\ B = B^*(t),\ t_0 \le t \le t_f^*$, μ_0, μ_1 and μ_2 are costate variables (not all zero) that satisfy $\mu_0 = \textit{constant} \ge 0$.

We can now state the necessary conditions for optimal control. The costate equations are

$$\dot{\mu_1} = -\frac{\partial H}{\partial K} = -\mu_1(F + K\frac{\partial F}{\partial K}) - \mu_2 B\frac{\partial G}{\partial K}, \tag{21}$$

$$\dot{\mu_2} = -\frac{\partial H}{\partial B} = -\mu_1 K\frac{\partial F}{\partial B} - \mu_2(G - uf + B\frac{\partial G}{\partial B}). \tag{22}$$

Since the controlled system (16) is a time-invariant one $\dot{H} = 0$, which implies that the Hamiltonian is constant on the optimal trajectory. Since this is a final-time-free problem, from the boundary condition $H(t_f) = 0$, [5] we obtain,

$$H(K^*(t), B^*(t), u^*(t), \mu(t)) = 0. \tag{23}$$

From the minimum principle, [6] with respect to all admissible controls,

$$H(K^*(t), B^*(t), u^*(t), \mu(t)) \le H(K^*(t), B^*(t), u(t), \mu(t)). \tag{24}$$

Since u appears linear in the Hamiltonian, we can claim the following. (The subscript denotes partial differentiation.)

Theorem 2 *There exists optimal bang-bang control as follows:*

$$H_u > 0 \Rightarrow u^*(t) = 0, \tag{25}$$
$$H_u < 0 \Rightarrow u^*(t) = u_{max}. \tag{26}$$

Further, although we omit the full proof, from Hirata's(1980) Proposition 1 and under our assumptions the optimal control of a debt reduction policy is almost always bang-bang control, which is a combination of $u = 0$ and $u = u_{max}$. [7] Theorem 2 tells us that the optimal policy to stabilize the credit cycles with minimum cost and in minimum time is to switch between the most extreme policies, no intervention and maximum debt reduction.

From Theorem 2, we can see that $H_u = \mu_0 - \mu_2 fB = 0$ provides the switching function. Here we avoid the explicit determination of the adjoint variables μ from

[5] Lewis and Syrmos (1995) p259–261 and Stengel (1994) p212–213.

[6] Because of the constraint $0 \le u \le u_{max}$, we cannot solve the problem by setting $\frac{\partial H}{\partial u} = 0$.

[7] The thrust of the proof of Hirata's(1980) theorem is that there is no singular control if only one variable (B in our case) is controlled and there are some assumptions about parameters (particularly $\dot{f} < 0$ in our case).

the necessary condition (21)–(24). (The difficulty of the problem is explained in Stengel (1994) p253.) Instead, following Hirata (1980) and Stengel (1994) p251–253, we derive the switching curve directly from the solutions to this system's dynamic equations, with u set at its limiting value. Substituting $u = 0$ and $u = u_{max}$ in the controlled system equations (16), we generate trajectories passing through the initial and final conditions by numerical simulation. Here, we discuss just the case with one switch in the control variable (Bang-bang control with two switches is analyzed in Goh, Leitman and Vicent (1974)). Optimal strategies are determined numerically and an example is shown in the Figure.

Numerical examples that are consistent with condition (11) can be considered as follows: $a = 0.2,\ b = 0.01,\ c = 1,\ d = 0.002$, and $p = 1/3$. Setting $e_1 = 1,\ \lambda = 0.001$, and $e_2 = 0.3$, the uncontrolled system of (7) and (8) (or the null control system) becomes

$$\dot{K} = (1 - 0.001K - 0.2B)K,$$

$$\dot{B} = (-0.3 + 0.006K)B.$$

With regard to the controlled system, we set $u_{max} = 0.5$ and $f(t) = e^{-0.3t} + 0.4$. Our simulation is based on the above numerical example. [8]

Let the initial state of the system be the point I. The bold line indicates the trajectory of the uncontrolled system, where $u = 0$. The dotted line indicates the trajectory of the controlled system, where $u = u_{max}$. The curve shown by a continuous sequence of arrows from the switching point S to the equilibrium point E is the switching curve, which is a segment of the maximum controlled trajectory. Under optimal control, the system is allowed to move under null control ($u = 0$) from I to S, at which point the control variable is applied at the maximum level $u = u_{max}$.

The optimal control law shown in the Figure has a clear policy implication. If the business cycles can be regarded as the predator-prey dynamics of capital and debt and the policy objective is to stabilize the economy with the minimum intervention cost in minimum time, then the optimal debt reduction policy such as bankruptcy reforms is as follows: While debt is decreasing (from I to A in the Figure), no intervention should be made. While debt and capital are both increasing (from A to B), again, no intervention should be made. While debt is increasing but capital is decreasing (from B to C), the appropriate switching should be located at point S, and at this point the debt should be reduced as much as possible by means of any policies, including bankruptcy reforms. Hence, the gist is that the switching point S lies in the region where the debt is increasing but the capital is decreasing.

There are many caveats regarding this policy prescription. The most important of these is how to locate the exact switching point. Moreover, the control with a single switch is only applicable within a certain region around the steady

[8] We refer to Berbstein (2003) to produce the MATLAB code of our simulation.

state. (See Goh, Leitman and Vicent (1974), Hirata (1980) and Stengel (1994) p251–253.) To control the system globally, one should analyze the bang-bang control with two switches, where the policy that implies changing from maximum debt reduction to null control can be taken into consideration. However, despite this, the above mentioned result may be appealing. The regime where the capital is decreasing and only the debt is increasing represents the pathological phase of an economy. Even if it is very difficult to determine the exact timing of the intervention, the government or the legislative body should take action during such a period. With regard to the debt reduction policy, the required policy is the maximum debt reduction.

In this sense, it is suggested that a sudden intervention in credit cycles through legislation of a new bankruptcy code that eases the cancellation of existing debt could be justifiable in some respects. In the next section, we examine some examples from the history of bankruptcy law and attempt to find the patterns of bankruptcy reforms as a response to business cycles. Further, we discuss whether these reforms have been desirable.

3 Examples from the History of Bankruptcy Law

In this section we consider as examples three major legislations from the history of the U.S. bankruptcy laws and one recent bankruptcy reform from the Japanese experience.

3.1 U.S. Bankruptcy Legislations

3.1.1 Bankruptcy Legislations and Economic Policy in the 1930s

During the Great Depression, the bankruptcy reforms proceeded in two directions: One was to protect small bondholders (creditors) and "punish" large bankrupt public companies (debtors); the other was new provision that made huge debt relief possible for farmers. Thus, the overall effect of debt cancellation appears to be ambiguous if one does not take other policy measures like the bailout of banks into consideration. However, at least to ease the farmers' debt burden, the states as well as the federal administration provided some drastic and even unorthodox measures for debt relief.

With regard to the large public companies, a new bankruptcy law named "Chandler Act" was enacted in 1938; it gave the court considerable administrative power to protect the general bondholders at the expense of large bond-issuing companies and small class of rich bondholders (Skeel (2001) p119–121). In this respect, the new act was pro-(junior-)creditor, although the overall volume of debt cancellation remains ambiguous.

The boldest debt cancellation at this time was provided for the benefit of farmers. The U.S.Congress enacted a new act called "Frazier-Lemke Act" in 1934, that gave farmers the right to redeem (buy back) their collateralized land from the bank. The value of such collateralized land had depreciated considerably at that time, and the difference between the existing collateralized debt and the price of the land was simply canceled. In other words, the farmers were only required to pay the collateralized (cheap) land price and the remaining debt was canceled. This legislation was harshly criticized by secured creditors, particularly bankers; however, the rule survived through the Great Depression era. It should be noted such a drastic debt relief measure was enacted merely as temporary legislation from the outset and the act was valid only until 1949, when the economy was stabilized (Yamamoto (1995)).

In addition to the Frazier-Lemke Act, which was also drastic, other policy interventions were also taken for debt cancellation. At first, states passed laws permitting debt moratoria for farm mortgages. To further improve farm income, the Roosevelt administration moved to devalue the dollar against gold. This devaluation would have triggered clauses giving creditors the option of demanding repayment in gold. However, the Congress abrogated all gold payment clauses, relieving debtors from making additional payments of $ 69 billion, which could have generated by the devaluation (Bolton and Rosenthal (2001)).

Thus, in the Great Depression era, when investment declined, the debt relief policy differed between large public companies and farmers. With regard to large firms like failed railroad companies, bankruptcy legislation was directed to protect small-size and scattered bondholders who were the creditors. The exact impact of this change on the volume of aggregate debt cancellation among such companies is uncertain. With regard to the farmers' debt relief, it can be stated that the Congress and the administration took every measure to cancel the debt of farmers to the furthest extent possible.

3.1.2 From The Bankruptcy Code of 1978 to the Present Time

After the long periods of boom (with short recessions) beginning from the second world war, the first half of the 1970s experienced a severe and long recession with declining private domestic investment. Again, many railroad companies failed. Following the bankruptcy of the Penn Central Railroad in 1970, other companies also went bankrupt, six of which were nationalized with the creation of Conrail in 1976 with outlays from the U.S. government. (Pagano and Volpin (2001)).

This recession in the first half of the 1970s and the frustrations of bankruptcy professionals like large law firms who lost the opportunity to earn fees under the stringent Chandler Act, motivated the repeal of the Act. As a result, the U.S.Congress enacted the Bankruptcy Code of 1978, which continues to dominate the bankruptcy procedure till date. Under the new Code, trustees are appointed only in exceptional cases, that is, the former managers of the bankrupt firm can continue to run the firm as "debtors in possession" (Skeel (2001) ch.6). The effect of this change is ambiguous with regard to the aggregate volume of debt cancellation. However, it can be surmised that more debt reduction is expected under the new rule because it gives the debtor incentives to file for bankruptcy.

From the 1990s, the major reform in consumer bankruptcy, which was probably the first pro-creditor reform in the history of post-war America, was debated and subsequently enacted in 2005. During the historically long period of boom in the 1990s, which was characterized by high investment level and rapidly growing debt, skyrocketing bankruptcy filings undoubtedly motivated the backlash from creditors. Further, because of the boom, the U.S. Congress (after long debates) supported the bill to make the discharge (cancellation) of consumer debt difficult. Although this change pertained to consumer debt, since the debt of owner-managers of small and medium size companies is also subject to the new legislation, at least some part of it can be and is regarded as the firm's debt.

3.2 Japanese Bankruptcy Reforms from the 1990s to the Present Time

After the collapse of the asset bubbles in 1990, Japan experienced a long period of recession with bad loan problems and low levels of investment. This period is sometimes called the lost decade. Since the Japanese bankruptcy laws had stringent German-style procedures, which took up a lot of time and were basically pro-creditor in nature, from the middle of the 1990s, thorough bankruptcy reforms were discussed to make the bankruptcy law easy to use both for debtors and creditors.

The reforms from 2000 to 2003 changed two major reorganization procedures. The Composition Law (Wagi Ho) was repealed and a new law, the Civil Rehabilitation Law (Minji Saisei Ho), was enacted in 2000. The Corporate Reorganization Law (Kaisha Kosei Ho) was reformed and became effective in 2003. The reforms heralded by these laws involved relaxing the majority voting requirements, restricting foreclosure (not debt relief) in case the debtor paid the collateral value, and relaxing the requirements for opening a bankruptcy case (Takagi and Abe (2002)).

With regard to debt relief itself, the most important reform in the Japanese context may have been the relaxation of the standards for opening a case. The effect of this revision was a rapid increase in filings under both laws, particularly the Civil Rehabilitation Law. It is considered the reason is not only the revision of the rule but also the transformed attitude of the court itself (Takagi and Abe (2002)). Once a case is filed, it is probable that a substantial part of the debt of the filing (or filed) firms is likely to be reduced either in reorganization procedure (in case the plan was confirmed) or in the liquidation procedure (in case the plan was unconfirmed). Thus, it would be relatively safe to claim that the Japanese recession during the 1990s enhanced the bankruptcy reforms and aided the faster cancellation of considerably more debt than was previously possible. It should also be noted that the 100 trillion yen (a trillion dollars) package to stabilize the financial system in 1998 was also one source of debt relief facilitated by the banking sector.

4 Concluding Remarks

The first part of this paper proposed a simple credit cycle model as a population dynamics and claimed that the optimal control of the system is bang-bang debt reduction, switching from no intervention to maximum debt reduction in the state of decreasing capital and increasing debt. The second part of the paper explained the actual interaction of the business cycles and bankruptcy reforms with the help of historical examples. In this concluding section, we briefly discuss whether the analysis of the first part could be useful to evaluate the real world bankruptcy reforms presented in the second part.

From the second part, we can see that the major bankruptcy reforms to date are responses to recessions, although there is one case of reform during a period of boom, and that macroeconomic factors are not the sole motive for reform. It can at least be stated there must be some interaction between economic dynamics and legal dynamics in this respect. The next question is whether bankruptcy reforms have been following the bang-bang debt reduction policy. A rough approximation of the second part can provide the following conclusion: In the U.S. in the 1930s, the degree of debt reduction appears to differ among sectors. It is ambiguous in the publicly held companies. However, in the agriculture sector, it shows typical bang-bang control characteristics. In either example, other policy measures like bailout policies should be included to assess the overall picture of debt relief. With regard to the bankruptcy reforms in 1978, it is unclear whether the maximum debt reduction occurred at that time, although the new rule gave managers of failed companies strong incentives to file for bankruptcy. With regard to the bankruptcy reforms in the U.S. in the 1990s where economic booms made pro-creditor, less debt reduction legislation possible — it might be regarded as a return to null control from the maximum control provided for by the 1978 Code; although it is difficult to define what the “null” control is. To assess this reform, it is necessary to analyze the optimal control model with two switches. Another typical bang-bang control example is provided by Japan in the 1990s. The institutional change was fundamental and debt reduction is expected to be rapid judging from the data of number of filed cases.

Thus, in our framework, the U.S.bankruptcy reforms for farmers in the 1930s and the Japanese bankruptcy reform in the 1990s (both with policies of debt reduction other than the bankruptcy reforms) could be considered desirable, if there were signs of both falling investment as well as rising debt. Further statistical analysis is a subject of future research. The above discussion reveals that there are certain historical examples that are relatively applicable to this analysis, and some that are not. A possible explanation for this is the magnitude and/or length of periods of recession and boom themselves. It is natural to believe that an extreme policy can be justifiable only in extreme circumstances. Another explanation can be found in the public choice literature about bankruptcy reforms, like Skeel (2001). Bankruptcy professionals, particularly in the U.S, seem to have a vested interest in bankruptcy both in and out of the court, and their motive appears to have been an important factor in influencing new legislation.

References

- Athreya K B (2002) Welfare implications of the Bankruptcy Reform Act of 1999. *Journal of Monetary Economics*, 49 (8): 1567–1595.
- Bernstein R (2003) *Population ecology : An introduction to computer simulation.* John Wiley and Sons, Ltd, West Sussex
- Bolton P and and Rosenthal H (2001) The political economy of debt moratoria, bailouts and bankruptcy. In: Pagano M (ed) *Defusing default: Incentives and institutions*, pp77–115. Inter-American Development Bank, Washington
- Conrad J M and Clark C W (1987) *Natural resource economics.* Cambridge University Press, Cambridge
- Goh B S, Leitman G and Vincent T L (1974) Optimal control of prey-predator system. *Mathematical Biosciences* 19: 263–286.
- Hirata H (1980) Optimal control of nonlinear population dynamics. *IEEE Transactions on Systems, Man, and Cybernetics*, SMC-10(1): 32–38.
- Kiyotaki N and Moore J (1997) Credit cycles. *Journal of Political Economy*, 105(2): 211–248.
- Krishnamurthy A (2003) Collateral constraints and the amplification mechanism. *Journal of Economic Theory*, 111: 227–292.
- Lewis F K and Syrmos V L (1995) *Optimal control (2nd Edition).* John Wiley and Sons, Inc, New York
- Li W and Sarte P D (2003) The macroeconomics of U.S. consumer bankruptcy choice: Chapter 7 or Chapter 13?

  (http://www.phil.frb.org/files/wps/2003/wp03-14.pdf)
- Paasche B (2001) Credit constraints and international financial crises. *Journal of Monetary Economics*, 48: 623–650.

- Pagano M and Volpin P (2001) The political economy of finance *Oxford Review of Economic Policy*, 17(4): 502–519.

- Skeel D (2001) *Debt's dominion: A history of bankruptcy law in America.* Princeton University Press, Princeton

- Stengel R F (1994) *Optimal control and estimation.* Dover Publications, Inc, New York

- Takagi S and Abe S (2002) The Japanese Corporate Reorganization Reform Law of 2002.

  $(http://www.iiiglobal.org/country/japan/Reformed_{C}orporate_{R}eorganization_{L}aw.pdf)$

- Yamamoto K (1995) Reorganization procedure for farmers in America. (in Japanese) *Waseda Ho-gakkai Zasshi* 45: 201–250.

- Yoshikawa H (2003) The role of demand in macroeconomics. *The Japanese Economic Review*, 54(1): 1–27.

- Zha T (2001) Bankruptcy law, capital allocation, and aggregate effects: A dynamic heterogenous agent model with incomplete markets. *Annals of Economics and Finance*, 2: p379–400.

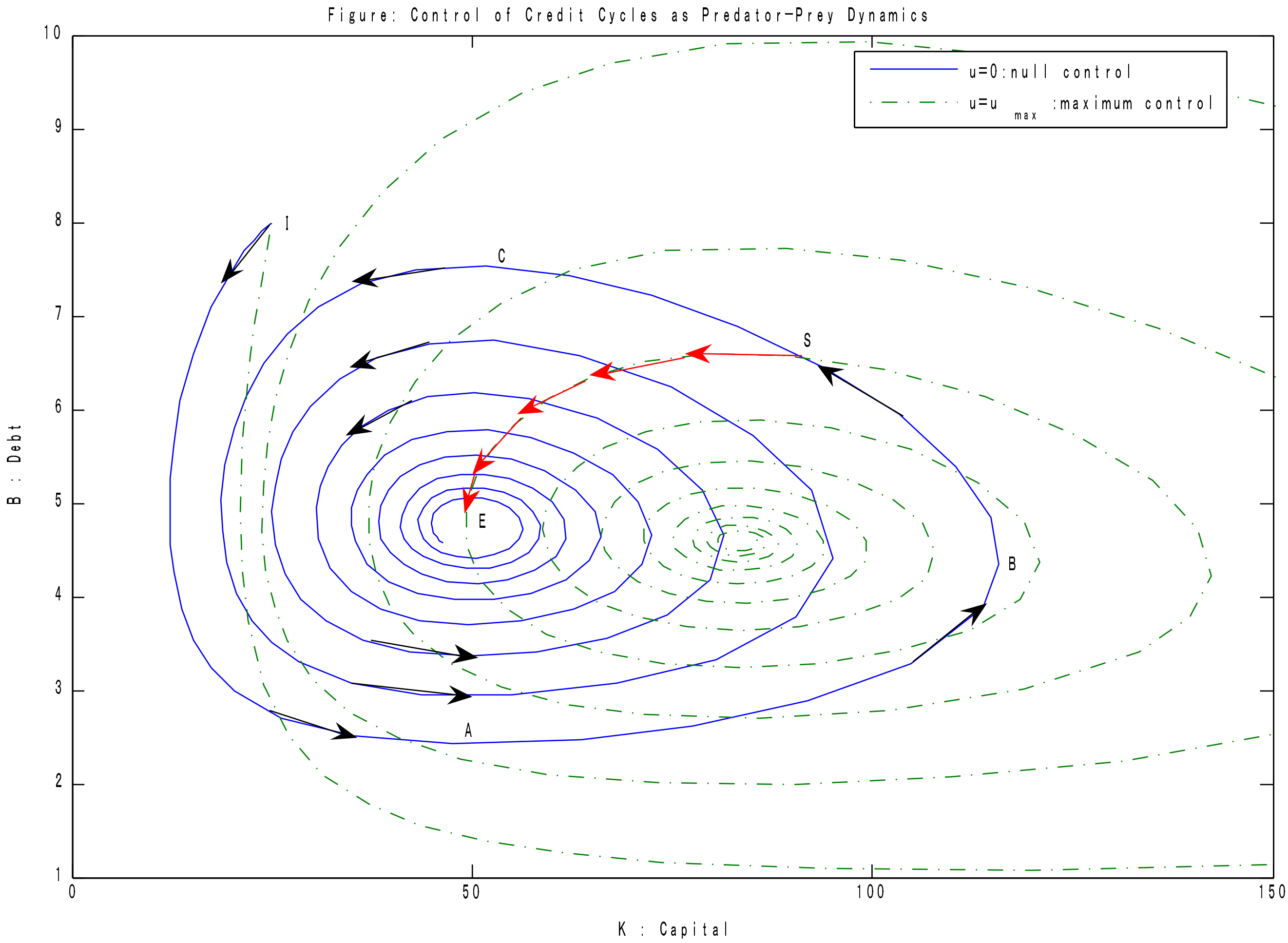
Figure: Control of Credit Cycles as Predator-Prey Dynamics
u=0:null control
u=u max :maximum control
B : Debt
K : Capital
I
C
S
E
A
B
0
50
100
150
1
2
3
4
5
6
7
8
9
10