

Government Debt and Sudden stops: A Coordination Game Preliminary Version

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October 26, 2005

Abstract

The model explains how high fiscal burden and coordination failure between investors trigger a growth collapse, which in turn results in a sudden stop. In contrast to the existing literature, we determine a unique threshold equilibrium applying global game theory: below a critical level of fiscal burden all players invest, inducing high growth, and above no one does. Comparative static analysis reveals that the probability of sudden stops decreases with technological progress and the precision of private signals on the fiscal burden, but it increases with the international interest rate. Additionally technologi-

cal progress and the interest rate influence the scope of government policies.

JEL classification: C 72, D 82, F 21, F32, F34

Keywords: Capital Flows, Government debt, Sudden Stops,
Global Games, Coordination Failure,

1 introduction

Eighty percent of the major financial crises in the past 30 years involved a sudden stop of capital flows into the crisis country.¹ In the literature, a sudden stop is defined as a sharp reversal in capital flows² associated with severe economic consequences. These consequences include a balance of payments crisis, a sudden loss of access to international capital markets, a collapse of domestic production and aggregate demand, and a sharp correction in asset prices and in prices of non-traded goods relative to traded goods. (cf. Arellano and Mendoza (2003) and Calvo (1998) for this definition.)

Financial crises that involved a sudden stop include the Latin American debt crises during the 1980s, the crisis experienced in south-east Asia in 1997 and Russia 1998. One of the most prominent financial crises, which even spread to other emerging countries around the world, was the Tequila crisis,

¹cf. list of headline financial crises in appendix (7.3). These crises were so severe, that the news about them went around the world and are remembered by most of us for the turmoil that they involved.

²These sharp negative variations are defined as the difference in flows between two periods relative to the GDP in the first period. A variation is considered relevant if it exceeds a specific threshold. The threshold levels and the flow concepts that are used as measures of sudden stops vary across authors. Calvo and Reinhart (2000), for instance, examine net private capital flows, Hutchison and Noy (2002) the changes in the current account. An alternative measure is the financial account.

that perturbed Mexico at the end of 1994 and beginning of 1995. Mexico experienced a reduction of net private capital flows of 4 percent of the GDP and went through a currency crises followed by a severe drop in output of 6 percent in the crisis year. During this time the country also plunged into a systemic banking crisis until 1997, including a temporary insolvency of 19 percent of the financial system assets.³

This example illustrates the implications of the financial turmoil in the context of a sudden stop and explains why this phenomenon has generated a large amount of academic work. The main objective of this paper is to include the possible coordination failure between private investors as a trigger of sudden stops into the analysis and to analyze its effect on the probability of a crisis. Thereby we wish to provide insights that help to prevent sudden stops. In addition, we aim at contribute to the discussion whether sudden stops depend on internal factors that first induce capital to flow into emerging markets and later on induce it to flow out in an abrupt manner (i.e. pull factors), or are a consequence of elements external to the crisis country (i.e. push factors).⁴

We base our analysis on the model presented in Calvo (2003) that explains

³cf. Caprio and Klingebiel (1999) and cf. list of headline financial crises in appendix 7.3.

⁴cf. for example Calvo et al. (1993) or Fernandez-Arias (1996)

the emergence of a sudden stop as being induced by a high fiscal burden that has to be financed through an output tax. A high fiscal burden (which is approximated by the level of government debt) reduces the attractiveness of domestic investments, inducing a potentially sharp negative movement in net private capital flows. In Calvo (2003), high taxes are detrimental to growth, implying a reduction in the capacity of the government to serve its debt and therefore perpetuating the necessity for high taxes. In this way, a sudden stop is rationalized on the basis of multiple equilibria. High (low) growth induces low (high) output taxes, which in turn generate high (low) economic growth. A crisis happens, if the economy discontinuously drops from the high growth to the low growth equilibrium.

In this mechanism, the role of debt is crucial to determine the tax rate and the associated output level. The model exhibits three distinct debt regions. For sufficiently low levels of debt, the government sets low output taxes and induces high growth. On the other extreme, where the debt is high, only low growth can be observed due to the negative impact of the required high taxes. However in an intermediate region the optimal action of a player depends on the actions of the other players. In this region the model displays two equilibria. Calvo assumes that coordination between investors occurs at zero cost. In his model, he considers a representative player. Therefore he assumes that coordination on high growth is always possible where the two

equilibria coexist. A sudden stop takes place when growth discontinuously switches from high to low growth. This switch occurs at the border of the multiplicity area, where the debt becomes so high that only the low growth equilibrium persists.

Calvo (2003) illustrates that in high growth equilibria the current account is negative, i.e. displays a deficit. This means that this economy consumes more than it produced. Therefore in the non-monetary economy that he presents first the difference has to be financed through capital inflows. When the growth rate discontinuously drops from high to low growth, the CA balance discontinuously switches to zero. This implies that the capital inflows must stop.

The rest of the turmoil entails a sudden stop in the following way: Assuming that consumption of non-tradables is a normal good, for a given real exchange rate, consumption of non-tradables falls as the net wealth decreases. Hence the growth collapse entails a fall in the volume of tradables which are the only production input for home goods. Thereby the marginal productivity of the tradables increases and this in turn suggests that a sudden stop is followed by a real depreciation. The collapse in GDP, that one empirically observes after a sudden stop stems from the collapse in production of non-tradables.

First of all, we reinterpret the Calvo setting as a coordination game be-

tween an infinite number of investors, who decide upon investment. In the intermediate region, if investors have perfect information concerning the debt, the multiplicity can be rationalized by the self-fulfilling nature of investors' beliefs. If the investors believe that a growth collapse and thereby a sudden stop occurs, it is optimal not to invest at all, which in turn induces government to set high taxes vindicating the decision not to invest. If in contrast investors believe in an favorable economic outcome, it is optimal for them to invest at the maximum. Hence government can set low taxes which then further justifies the decision to invest and so forth.

We relax the unrealistic assumption of perfect coordination between private investors. We can show that there exists a unique threshold equilibrium by applying the methodology of global games. Below this threshold private investors coordinate on the high growth equilibrium. Above no one invests. Thereby the economy drops to the low growth equilibrium, although the state of the fundamentals would still support the high growth equilibrium. Global games were first presented in Carlsson and van Damme (1993) and then prominently applied to the explanation of currency crises by Morris and Shin (1998). In our setting, investors receive a private signal on the level of debt, which is dispersed with a small amount of noise around the true value of the debt. In this setup, in the intermediate debt region only a small deterioration of the level of debt is necessary to exceed the private signals to

exceeds the threshold signal, leading to coordination failure.

The main contribution of this paper are a unique threshold equilibrium and the comparative static analysis of this equilibrium. The comparative static analysis allows us three insights: First, the probability of a sudden stop decreases with technological progress. Second, it increases with a higher international interest rate and third, the probability of a sudden stop also rises with noisier signals. In terms of policy instruments this means, that technology-enhancing policies or policies that ameliorate the investment safety help prevent sudden stops as well as information dissemination strategies that lead to little noise in the private signals. The international interest rate is an external factor so policy makers of a specific country cannot influence it. This leads to the other set of results: We find, that with increasing international interest rate, the scope of policy action, preventing a sudden stop, is reduced. In contrast, with technological progress, government gains scope for its actions. Hence, in terms of the discussion regarding pull and push factors of capital flows, we find, that in times when external factors are unfavorable for an economy, they are also dominating.

The present work combines two distinct literatures. First of all, the methodology that we apply to solve for the unique equilibrium stems from the literature on global games. The latter has been introduced by Carlsson and van Damme (1993) who describe the investment decision of two strate-

gically interacting agents. One of the most prominent applications of this methodology has been to currency crises by Morris and Shin (1998). They find a unique threshold equilibrium at which the coordination changes from "attack" to "no attack" on the currency. In addition, they also conduct a comparative static analysis and discuss policy implications. Their set-up is closely linked to ours although they have constant payoffs in case of no attack. Methodologically our work is most closely linked to Doenges and Heinemann (2001). The discussion of the information dissemination policy of the government has first been conducted by Heinemann and Illing (2002).

Secondly, we draw on the extensive literature of sudden stops. This literature can be divided into numerically solvable real business cycle models with credit frictions and into analytically solvable new Keynesian models. Arelano and Mendoza (2003) provide a comprehensive survey on the existing literature on the RBC type models. The challenge of that literature is that the models are not analytically solvable and their quantitative implications have not been sufficiently tested.

We contribute to the analytically solvable models of sudden stops. The idea of rationalizing capital outflows by public debt that has to be financed by output taxes, stems from Eaton (1987). Calvo (1994) takes up Eaton's basic idea, transforms it into a dynamic optimization of investors and makes it compatible with questions about growth. However, the main interest of

that paper is whether capital controls can help countries to get on a growth path that enables economic transformation and hinders capital flight. Calvo (2003) then applies the previous set-up explicitly to the question of sudden stops and explains how the sudden stop in capital inflows leads to a currency crisis, a balance of payment crisis and a drop of the GDP. This model is also closely linked to Calvo (1998) where the author presents a clear characterization of an ability to pay framework as a mechanism for explaining sudden stops. The shortcoming of that literature is the multiplicity of equilibria which makes predictions of sudden stops impossible and restricts policy advice. The present work is a step in the direction to alleviate this problem.

The paper is organized as follows: In section (2) we present the model. In sections (3) and (4) we interpret the problem in terms of a coordination game: First we present the common knowledge game and then the setting with private information on the state of the debt. The latter comprises the discussion of the uniqueness of the equilibrium. Section (5) provides a comparative static analysis of the problem and derives policy implications. Finally section (6) concludes the paper.

2 Model Set Up a la Calvo

Our model is based on the framework presented in Calvo (1994) as well as Calvo (2003). We depart from the Calvo set up by introducing a continuum of infinitely existing, identical companies of mass one. This allows us to reinterpret the original model in terms of a coordination game with common knowledge. In chapter (4) we depart further from Calvo (2003) and introduce private signals on the fundamentals, allowing us to solve and analyze the private information game.

2.1 The Firms

Each of the infinitely many firms produces tradable output with a linear homogeneous production function. Tradable capital is the only production factor, which is fully internationally mobile ex ante but immobile after investment. $y_t^i = \alpha K_t^i$. In every period t the firms earn a cash flow of:

$$S_t^i = \alpha(1 - \tau)K_t^i - \dot{K}_t^i \quad (1)$$

τ represents a constant output tax rate and $\dot{K}$ the rate of capital accumulation, neglecting capital depreciation.

The value of the firm at time zero is defined as the sum of discounted future cash flows:

$$V^i = \int_0^\infty S_t^i e^{-rt} dt \quad (2)$$

where r represents the constant international interest rate.

We define $z^i = \frac{\dot{K}^i}{K^i}$. Due to the linear technology, z^i not only represents the rate of capital accumulation but also the rate of output growth. Normalizing the initial capital stock to one, the value of the firm can also be expressed as

$$V^i = \int_0^\infty [\alpha(1 - \tau) - z_t^i] e^{-\int_0^t (r - z_s^i) ds} dt \quad (3)$$

We take into account that the firms consider the technology parameter, the tax rate and the international interest rate as given, when choosing between growth paths z in order to maximize their value. Therefore the above expression simplifies to:⁵

$$V^i = \frac{\alpha(1 - \tau) - z^i}{(r - z^i)} \quad (4)$$

Optimizing the value of the firm with respect to the rate of capital accumulation leads to:

$$\frac{\partial V^i}{\partial z^i} = \frac{\alpha(1 - \tau) - r}{(r - z^i)^2}$$

⁵For a detailed derivation please regard appendix 7.1. The firms expect the tax rate to be constant, because a sudden stop is unexpected to them. In the light of possible growth collapses and ensuing sudden stops a different tax policy τ_t might be optimal for the government. Therefore firms would expect the tax rate to change once a crisis occurs. Calvo (2003) can show in his paper that the growth collapse and the sudden stop also occur in the case when they are foreseen by the firm. So we do not consider the case of an anticipated crisis here.

The model obviously delivers corner solutions: On the one hand, if the after tax return on capital exceeds the international interest rate, it is optimal for a firm to invest as much as possible. On the other hand, if the return on capital is lower than the interest rate, the firm does not accumulate capital at all, it even borrows as much capital as possible and invest it abroad. Therefore in order for the model to deliver a sensible outcome, it is necessary to restrain the parameter z^i and thereby z^{econ} to finite "corners". The value of z^i is restricted to an interval from $[0, \bar{z}]$ with $\bar{z} < r$, where the lower bound ensures that capital cannot be unbolted and the upper bound stands for reasonable outcomes with respect to the valuation of the firms. A firm will not invest if the value of the firm is reduced. So it is sufficient to consider the sign of the derivative of V^i with respect to z^i .

$$sgn \frac{\partial V^i}{\partial z^i} = sgn[\alpha * (1 - \tau) - r] \quad (5)$$

2.2 The Government

The government inherits a stock of debt, D , which has to be financed via an output tax. The tax rate is set such that the future discounted tax revenues cover the amount of debt. This is possible assuming full capital market access by the government.

$$D = \alpha\tau \int_0^\infty K_t^{econ} e^{-rt} dt = \frac{\alpha\tau}{r - z^{econ}} \quad (6)$$

with

$$z^{econ} = \frac{\int_0^1 \dot{K}^i di}{\int_0^1 K^i di} = \frac{\dot{K}^{econ}}{K^{econ}}$$

2.3 The Reduced Form Game between Firms

Government appears in the model in order to explain the strategic complementarity between the firms and the dependence of the investment decision on the fundamentals: the profit of investment for an individual company positively depends on the amount of investment of all other firms. This can be shown by solving equation (6) for τ and then plugging it into (5). The value of the firm is now a positive function of z^{econ} and a negative function of the debt.

$$sgn \frac{\partial V^i}{\partial z^i} = sgn[\alpha - D(r - z^{econ}) - r] \quad (7)$$

The value of the firm is increasing in z^{econ} . This means that the value of the firm rises with the share of other players investing. This is due to the fact that then the burden of debt repayment is carried by more agents.

In addition it is obvious that the value of the firm is decreasing in the debt burden.

The main mechanism underlying the interaction of agents consists of the fact, that, if growth is high, the government sets a low tax rate, which in turn sustains high growth. Analogously if growth is low, the government has to

set a high tax rate holding firms off investing, which in turn further induces low growth.

3 The Common Knowledge Game

Let us assume now, that all the firms and the government know the true values of the relevant variables.

3.1 High Growth and Low Growth Equilibrium

Equation (7) can be used to illustrate the area of existence of a low growth and a high growth equilibrium. On the one hand a low growth equilibrium can exist where a firm does not have an incentive to deviate from its strategy not to invest, given, that the other firms which are all identical do not invest. This is the case, when equation (7) displays a negative value in the case that $z^{econ} = 0$. When solving for D , we find, that the low growth equilibrium exists in the case that the debt is higher than a threshold:

$$D > \underline{D} = \frac{\alpha - r}{r}$$

On the other hand a high growth equilibrium exists, when a firm does not have an incentive to deviate from the strategy to invest, given that the other firms do also invest. In terms of equation (7) this means that a high growth

equilibrium exists, if the signum of the equation is positive for $z^{econ} = \bar{z}^{econ}$.

Thereby we find, that the high growth equilibrium exists below a threshold:

$$D < \bar{D} = \frac{\alpha - r}{r - \bar{z}^{econ}}$$

3.2 The Tripartite Classification of Fundamentals

By definition $0 < \bar{z}^{econ} < r$ and $\alpha > r$. Therefore it is clear from the two equations in section 3.1 that $\bar{D}$ is bigger than $\underline{D}$. This constellation of the thresholds suggests, that the level of debt can be classified into three areas. Between the two threshold values, $\bar{D}$ and $\underline{D}$, the two equilibria coexist. Above $\bar{D}$ only the low growth equilibrium exists and below $\underline{D}$ only the high growth equilibrium.

Intuitively the tripartite classification can be explained by the fact, that on the one hand there exists a level of the debt that is so low that it will pay for an individual firm to invest, irrespective of the actions of all other firms, for instance a zero debt. In the present model, the tax on the output would then be zero as well. By assumption the return on capital in the country, α , exceeds the return on the international capital market, r , thus the expected payoff of investing would always be positive if the debt or the tax was zero (cf. equation (7) for $D = 0$ and $z^{econ} = 0$, $z^{econ} = 0$ being the worst thing a firm has to expect because of strategic complementarity).

If a player chooses a specific action irrespective of the actions of all other players and does not have an incentive to deviate, then the first player's action is called a dominant strategy. The area of fundamentals for which players have dominant strategies is called dominance region.

Now we can classify the fundamentals. If D is smaller than $\underline{D}$, the economy will for sure be in a low growth equilibrium. If D lies between $\underline{D}$ it is not clear whether agents can coordinate on the high growth equilibrium or whether coordination failure occurs and the economy is captured in the low growth equilibrium. If D exceeds $\bar{D}$ the economy displays low growth with certainty. The threshold cases, where $D = \underline{D}$ and $D = \bar{D}$ are not of interest and will therefore not be discussed. The tripartite classification of fundamentals is illustrated in figure 1.

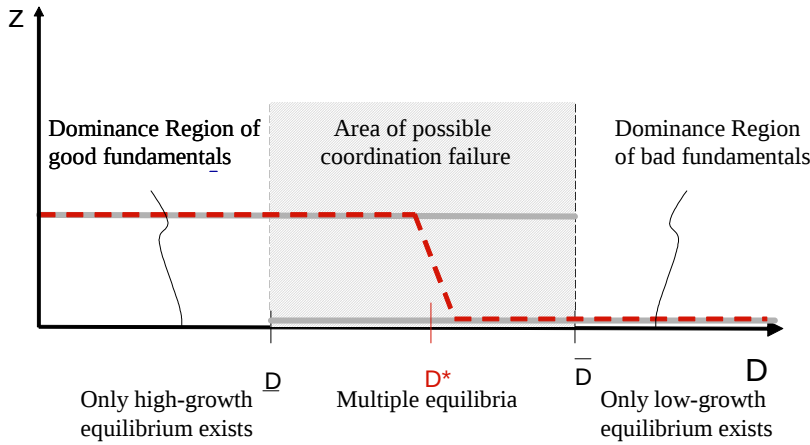


Figure 1: Model set up

Figure (1) shows the existence of the high and the low growth equilibrium as a function of the level of government debt. In case of common knowledge the model displays an indeterminacy between the high and the low growth equilibrium for those levels of debt, where both equilibria coexist. In section (4) however, we will be able to determine a threshold signal of the debt, D^* , below which investors can coordinate to high investment, thus leading to high growth. Above this level of debt, investors then decide not to invest, thereby inducing low growth.

4 The Private Information Game

In the common knowledge game we have found the area of multiplicity of equilibria between $\underline{D}$ and $\overline{D}$. This imprecision can be eliminated by introducing private, slightly noisy information on the state of the fundamentals. In the two following sections we will first show the uniqueness of the equilibrium and then analyze how the threshold equilibrium is influenced by changes in the technology parameter, by changes in the international interest rate and by changes in the imprecision of the signal.

4.1 Informational Structure

The players cannot observe the true value of the debt but receive noisy signals D^i on the state of the debt. The true level of the debt is uniformly distributed over a sufficiently large support.⁶ The signals are privately observable and uniformly distributed in an ϵ surrounding of the true value of the debt, D , $[D - \epsilon, D + \epsilon]$. The players know about all other firms that they also receive a private signal. In addition each player i knows the support and the distribution from which the realizations of D are drawn.

The fact that the signal on the state of the debt is private, reflects, that agents interpret officially announced values of the government debt differently. In addition the fact that the levels of debt are often revised ex post from official institutions enforces the importance of interpretation of the information and justifies the signals on debt being private.

In order to derive a unique equilibrium it is important to make sure that the signal is informative about the true level of the debt. Otherwise the players would not have an idea about the true value of debt and about the possible signals that the other players receive, given their own signal. As

⁶sufficiently large in this context means, that the support of D must exceed the borders of the multiplicity area in terms of the true value of the fundamentals by at least more than ϵ each. This is required in order to ensure the existence of dominance regions in the private information game.

shown in Heinemann (2001) the distributional assumptions that we make in the current set up ensure that this requirement is fulfilled.

4.2 Dominated Strategies

Suppose that the support of the debt $[\check{D}, \hat{D}]$ exceeds $\underline{D}$ and $\overline{D}$ (the borders of the multiplicity area in terms of the true value of the fundamentals, which were found in the previous section) by at least more than ϵ each. Then there exist signals $\underline{D}^0$ and $\overline{D}^0$, such that

$$E(D|\underline{D}^0) = \underline{D} \quad \text{and} \quad E(D|\overline{D}^0) = \overline{D}$$

Due to the monotonicity of the conditional expectation, $E(D|D^i) < \underline{D}$ for signals $D^i < \underline{D}^0$ and $E(D|D^i) > \overline{D}$ for signals $D^i > \overline{D}^0$. Referring to the results from the section 4.1, it is clear that, assuming rational players, agents who receive a signal below $\underline{D}^0$ will always invest. Investing less than the maximum is a dominated strategy for those signals. At the other extreme of the distribution signals above $\overline{D}^0$ will induce players not to invest, i.e. for those signals investing is the dominated strategy.

4.3 Object of Optimization

The firms cannot observe the true value of D in the private information set up, but only have an expectation about it, given the private signal that they

receive.

$$E(D|D^i) = E\left(\frac{\alpha\tau}{r - z^{econ}}|D^i\right) \quad (8)$$

Due to the fact that the expectation of D depends on the private signal and z^{econ} does as well, the firms have an expectation about the tax rate that the government will set, given their private signal:

$$E(\tau|D^i) = E\left(\frac{D * (r - z^{econ})}{\alpha}|D^i\right) \quad (9)$$

Therefore, the expectation of the value of the firm depending on the level of investment can be expressed as:

$$E(V|D^i) = E\left(\frac{\alpha - D * (r - z^{econ}) - z^i}{r - z^i}|D^i\right) \quad (10)$$

It is clear from equation (10) that the value of the firm is monotonically decreasing in D^i and increasing in z^{econ} . This is analogous to the common knowledge game and makes clear that the optimizing behavior in the private information game is in principle similar to the behavior under common knowledge. Just as in the private information game, the firms compare the expected difference in payoffs following from alternative strategies.⁷ As shown before, the extreme strategies of investing at the maximum versus not investing at all dominate all intermediate strategies. So it suffices to compare the expected payoffs of these two strategies. Precisely, in the present set up

⁷cf Doenges and Heinemann (2001)

the relevant measure is the expected difference in the value of the firm, in case of maximum investment versus no investment at all⁸:

$$\tilde{U}(D^i) = E\left(\frac{\alpha - D(r - z^{econ}) - \bar{z}^i}{r - \bar{z}^i} - \frac{\alpha - D(r - z^{econ}) - 0}{r - 0} \middle| D^i\right)$$

We know, that in the case of unbiased signals around the true value the expectation of the true value of an variable given the private signal that individual i receives is the signal itself: $E(D|D^i) = D^i$. Therefore the above expression can be simplified to:

$$\tilde{U}(D^i) = \bar{z}^i * \frac{\alpha - r - rD^i + E(D * z^{econ}|D^i)}{(r - \bar{z}^i)r} \quad (11)$$

4.4 Switching Strategies

In order to derive a unique equilibrium we need a further ingredient: a switching strategy. A switching strategy means, that a firm invests with probability one, if and only if, the signal it receives is below a threshold D^k and abstains from investing with probability one, if the signal is above the threshold: ⁹

$$I_{D^k} = \begin{cases} 1 & \text{if } D^i < D^k \\ 0 & \text{if } D^i \geq D^k \end{cases} \quad (12)$$

⁸In the following this will simply be referred to as payoff difference

⁹By continuity arguments it is possible to show, that such a simple switching strategy is optimal. So one does not sacrifice generality when imposing it in the first place.

¹⁰In terms of the payoff the behavior of the agents in a single event is irrelevant. There-

In addition in a game with infinitely many players one can interpret z^{econ} either as probability that all the other players j receive signals below the threshold signal of the switching strategy, D^k or as the fraction of other firms that invest. In case that all other firms follow a switching strategy of I_{D^k} the payoff difference can be expressed in the following way ¹¹:

$$\tilde{U}(D^i, I_{D^k}) = \bar{z}^i * \frac{\alpha - r - rD^i + \bar{z}E(D * \text{prob}(D^j < D^k)|D^i)}{(r - \bar{z}^i)r} \quad (13)$$

To obtain equation (13) we have expressed z^{econ} as the probability that all other players receive a signal below the threshold signal times the maximum possible investment.

4.5 Iterated Elimination of Dominated Strategies

At this point it is possible to start the process of the iterated elimination of dominated strategies: By excluding more and more dominated strategies from both extremes of the multiplicity area it is possible to narrow this area down. The purpose of section (4.6) will then be to show, that one can even eliminate the multiplicity at all and find a unique equilibrium in the described setting.

fore it is also irrelevant, whether players invest at $D_i = D_k$ or not

¹¹All firms are identical so they will have identical switching strategies.

One starts the elimination at the borders of the multiplicity area. As we have seen before, the relation between different firms is characterized by strategic complementarity: It is best for a firm, if all the other firms invest for as many signals as possible. So in the present context the best outcome a firm can expect is that the other firms follow a switching strategy with threshold value $\overline{D}^0$. The worst thing a firm must expect is, that all the other firms follow a switching strategy, where the threshold value is exactly $\underline{D}^0$.

It can be shown that the function $\tilde{U}(D^i, I_{D^k})$ is strictly monotonically decreasing in D^i .¹² With decreasing signal D^i the probability increases, that $D < D^k$. This means that the probability increases, that the other players invest. Therefore the expected payoff difference increases with decreasing D^i .

Due to the strict monotonicity in D^i , there exist unambiguous signals $\overline{D}^1 < \overline{D}^0$ and $\underline{D}^1 > \underline{D}^0$, such that

$$\tilde{U}(D^i, I_{\overline{D}^0}) < 0 \quad \text{for all} \quad D^i > \overline{D}^1 \quad \text{and} \quad \tilde{U}(D^i, I_{\underline{D}^0}) > 0 \quad \text{for all} \quad D^i < \underline{D}^1$$

Given that the other players do not invest when receiving signals above $\overline{D}^0$ the investment does not pay for signals above $\overline{D}^1$ either. This process can be iterated. Given that the other players do not invest when receiving signals above $\overline{D}^n$ it does not pay to invest at a signal $\overline{D}^{n+1}$ with $\overline{D}^{n+1} < \overline{D}^n$. The signals $\overline{D}^{n+1}$ are found by setting the expected payoff difference to 0,

¹²cf. appendix (7.2.2) for the proof.

reflecting indifference between investment and no investment at firm i :

$$\tilde{U}(\overline{D}^{n+1}, I_{\overline{D}^n}) = \bar{z}^i * \frac{\alpha - r - r\overline{D}^{n+1} + \bar{z}E(D * \text{prob}(D^j < \overline{D}^n) | D_i = \overline{D}^{n+1})}{(r - \bar{z}^i)r} = 0 \quad (14)$$

The sequence $\overline{D}^n$ is decreasing. One continues the iteration until one finds a value $\overline{D}^*$ such that

$$\tilde{U}(\overline{D}^*, I_{\overline{D}^*}) = 0 \quad (15)$$

At the lower bound of the multiplicity area the analogue situation occurs, just with the sequence $\underline{D}^n$ being increasing. There one iterates until one finds:

$$\tilde{U}(\underline{D}^*, I_{\underline{D}^*}) = 0 \quad (16)$$

. That means, one iterates until one finds the signal at which player i is indifferent between investing and not, and which is at the same time the threshold of the switching strategy of all players.

The switching strategies $I_{\underline{D}^*}$ and $I_{\overline{D}^*}$ are Nash equilibria of the private information game. Following Milgrom and Roberts (1990) one knows that in all games with strategic complementarity the highest and the lowest equilibrium, that resist the iterative elimination are Nash equilibria. Or the other way round: Nash equilibria can never be eliminated. Thus $I_{\underline{D}^*}$ and $I_{\overline{D}^*}$ are the most extrem Nash equilibria of the game. In case that

$$I_{\underline{D}^*} = I_{\overline{D}^*} \quad (17)$$

there exists a unambiguous signal D^* , below which in equilibrium all players will invest and above which no player will invest.

4.6 Unique Equilibrium

Proposition 1 *There exists a unique threshold equilibrium D^* of the game with imperfect information, such that all the firms invest if and only if $D^i \leq D^*$ and do not invest if $D^i > D^*$.*

The uniqueness of equilibrium can be proved by showing that there is a unique D^* , such that the equations (15) and (16) are fulfilled. This means that in a first step one has to find a unique solution to the equation:

$$\tilde{U}(D^i = D^*) = \bar{z}^i * \frac{\alpha - r - rD^* + \bar{z}E(D * \text{prob}(D^j < D^*)|D_i = D^*)}{(r - \bar{z}^i)r} = 0 \quad (18)$$

In addition one also has to make sure that $\tilde{U}$ is strictly monotone in D^i . The latter step ensures that there cannot be more than one value for which equation (18) holds true.

Solving equation (18) delivers a value of D^* of ¹³:

$$D^* = \frac{\alpha - r - \frac{\epsilon}{6}\bar{z}}{(r - \frac{1}{2}\bar{z})} \quad (19)$$

Additionally, in terms of monotonicity we can show that¹⁴

¹³The detailed proof can be found in appendix (7.2)

¹⁴The detailed proof can be found in appendix (7.2.2)

$$\frac{\partial \tilde{U}}{\partial D^i} < 0 \tag{20}$$

Therefore we can conclude that there exists a unique equilibrium.

By applying the methodology of global games we have been able to eliminate the area of multiplicity. We are now able to predict when a growth collapse occurs. In the Calvo set up a growth collapse automatically entails a sudden stop. So the above analysis not only lays bare how the economy will plunge into a growth collapse but at the same time explains the onset of a sudden stop of capital flows. It is of interest to know how the change of economic variables alters the threshold and thereby the probability of a sudden stop

5 Comparative Statics

In this section we analyze how a change in the productivity of the country, a change in the international interest rate and a change in the noise in the information on the debt influence the value of the threshold equilibrium at which the growth collapse and therefore the sudden stop take place.

5.1 Changes in the technology parameter α

First of all we analyze the technology parameter, which is in the model equivalent to the productivity of capital.

Proposition 2 *If the technology parameter α increases, the threshold equilibrium lies at a higher level of debt, ie. a growth collapse and thereby a sudden stop occurs at higher levels of debt only.*

The correctness of proposition (3) can easily be illustrated. In terms of equations of the model we find the effect of α on the threshold equilibrium by differentiating equation (19) with respect to α .

$$\frac{\partial D^*}{\partial \alpha} = \frac{1}{(r - \frac{1}{2}\bar{z})} > 0 \quad (21)$$

The above expression must always be positive, because r is bounded to be bigger than $\bar{z}$.

The result of the differentiation means, that with increasing productivity the switch from high to low growth equilibrium only happens for higher debt levels. In the sense that one thing of a finite support of the distribution of the debt. One could say, that the probability of a growth collapse decreases and therefore the probability of a sudden stop. In figure (2) this is mirrored by D'^* lying right of D^* with α' being bigger than α .

One finds another interesting result, when looking at the change of the borders of the multiplicity area with a change in the technology parameter.

Proposition 3 *If the technology parameter α increases, the gap between D^* and $\bar{D}$ widens, i.e. the area of inefficiency due to coordination failure increases.*

The derivative of the lower bound of the multiplicity area, $\underline{D}$, is smaller than the derivative of the threshold equilibrium, which in turn, is smaller than the derivative $\bar{D}$.

$$0 < \frac{\partial \underline{D}}{\partial \alpha} = \frac{1}{r} < \frac{\partial D^*}{\partial \alpha} = \frac{1}{(r - \frac{1}{2}\bar{z})} < \frac{\partial \bar{D}}{\partial \alpha} = \frac{1}{r - \bar{z}} \quad (22)$$

As illustrated in figure (2) the area of multiplicity enlarges with bigger α . Between D^* and $\bar{D}$ is the area, where the low growth equilibrium prevails due to coordination failure, although in terms of the fundamentals still the high growth equilibrium is possible. One could argue that the size of this area could be seen as a measure of inefficiency of the economy. Then one would argue, that with increasing α the inefficiency of the economy increases. However this view is incorrect as simultaneously also the area between $\underline{D}$ and D^* increases by the same amount. For these levels of debt, the investors coordinate to the high growth equilibrium although also the low growth equilibrium

exists. It seems to be a more convincing to state, that the overall situation improves because first of all the probability of a sudden stop decreases (as argued above) and second, the area between D^* and $\bar{D}$ can be seen as an area, where the government can improve the situation by helping investors to coordinate. So we can rather say that technological progress accords a larger scope to government policy to enhance coordination.

We also see, that the effect of α decreases in r . This can be explained by the fact that the scope of action for the government is reduced, when external factors, such as the international interest rate, change. It is informative to analyze the direct effect of a change in the international interest rate on the threshold equilibrium.

5.2 Changes in the international interest rate r

Proposition 4 *If the international interest rate, r , increases, the threshold equilibrium lies at a lower level of debt, ie. a growth collapse and thereby a sudden stop occurs already at lower levels of debt.*

A change in the international interest rate produces the following effect:

$$\frac{\partial D^*}{\partial r} = \frac{(3 + \epsilon)\bar{z} - 6\alpha}{6(r - \frac{1}{2}\bar{z})^2} < 0 \quad (23)$$

The denominator of the fraction in equation (23) must always be positive. The numerator is negative for possible values of α and ϵ . Per definition α

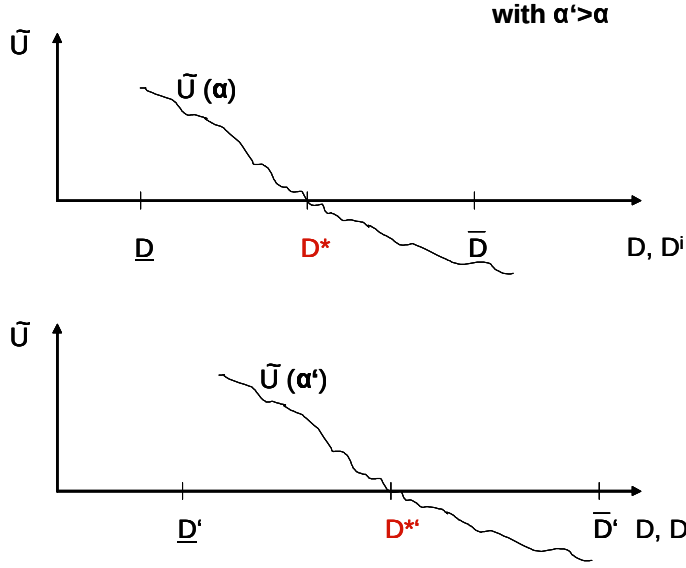


Figure 2: Changes in D^* and the borders of the multiplicity area due to changes in α

must exceed r , which in turn must exceed $\bar{z}$. ϵ is restraint to small numbers, for sure smaller than three, which would be the solution, when setting the numerator to zero for the case that $\alpha = \bar{z}$. The effect of a change of r on D^* is negative; i.e. if the international interest rate increases, D^* moves to the left in figure (2). In terms of the real economy this implies, that with higher international interest rates, sudden stops occur for lower levels of debt.

When doing the comparative static analysis at the borders of the multiplicity area one finds that the derivative of $\bar{D}$ with respect to r is more negative, than the one of $\underline{D}$. This result implies, that the area of multiplicity shrinks with increasing r . With the analogous argument to the one we used

for the comparative statics of α , we conclude that the scope of government policies is thereby diminished.

Again we see in this comparative static the opposing effects of α a parameter determined in the respective country and r , a parameter which is independent of the situation in the particular country.

These results of the comparative statics with respect to α and r are fully in line with the empirical literature on pull and push factors with respect to capital flows.¹⁵ As a large part of the mentioned literature tries to explain the surge of capital inflows into developing countries, "pull" refers to the factors that lie inside the economy and attract the capital inflows. Montiel and Reinhart (1999) define these capital attracting factors as the ones that operate through the improvements in the risk-return characteristics of assets issued by the developing country debtors such as would result from productivity enhancing economic reforms.¹⁶ So in our set up this would mean policies, that lead to an increase of the technology parameter α .

In contrast to the "pull" factors, the "push" factors lie in the industrialized countries. The most prominent factor mentioned in the literature is

¹⁵cf. e.g. Calvo et al. (1993), Calvo et al. (1996), Diaz-Alejandro (1983), Fernandez-Arias (1996), Montiel and Reinhart (1999).

¹⁶In addition Calvo et al. (1993) mention introduction of institutional reforms such as liberalization of the domestic capital market, opening of the trade account and policies that result in credible increases in the rate of return on investment.

the world interest rate.¹⁷ In their paper on inflows of capital to developing countries in the 1990s Calvo et al. (1996) mention that the low interest rates in the developed countries attracted investors to the high investment yields and improving economic prospects of economies in Asia and Latin America in the beginning of the 1990s. For example the short term interest rate in the USA reached its lowest point since the early 1960s in 1992. Fernandez-Arias (1996) contributes an interesting twist to the question of the influence of external factors to capital flows to emerging markets by laying bare, the positive effect of lower world interest rates on the creditworthiness of debtor countries that borrow at these rates. This is a further channel through which low world interest rates may induce capital to flow into emerging markets.

In the mentioned literature it is disputed, whether the external or internal factors are more important in the determination of the direction and composition of the flows. We cannot determine with our model, whether internal or external factors are more important, but we can illustrate in our model, that the scope of government policies coping with possible coordination failures changes as a function of external factors. If the international interest rate increases governments of developing countries lose scope whereas they

¹⁷As stated in Calvo et al. (1996) additional external factors include terms-of-trade developments, international business cycle, regulatory changes that affect the international diversification of investment portfolios at the main financial centers.

gain if the interest rate falls. We find in accordance with the empirical literature, that the government can buy scope of its policies by for example productivity enhancing reforms. But at the same time we have to say, they lose if the productivity is decreased. This means, that we would expect the relative importance of internal versus external factors varies over time. And we would expect this change to be such that in unfavorable surroundings for the country the government can do even less.

5.3 Changes in the noise on the private signal on the level of debt ϵ

Finally it is interesting to look at the impact of a change in the precision of the information *epsilon*:

Proposition 5 *If the noise ϵ in the signal increases, the threshold equilibrium lies at a lower level of debt, ie. a growth collapse and thereby a sudden stop occurs already at lower levels of debt.*

That proposition (5) holds true can easily be seen by taking the derivative of D^* with respect to the variance of the signal around the true value of debt.

$$\frac{\partial D^*}{\partial \epsilon} = -\frac{\bar{z}}{6(r - \frac{1}{2}\bar{z})} < 0 \quad (24)$$

For possible values of r the derivative is always negative. This means that D^* decreases with increasing noise. As argued before this in turn implies, that the probability of a sudden stop increases. Formulated differently this means that the more precise the information, the lower the probability of a bad equilibrium. This result contrasts the findings of the "game of refinancing".¹⁸. In terms of government policies it means, that governments should aim for a information dissemination policy that entails small variation in the value of private signals.¹⁹

We have shown that there exists a unique threshold equilibrium describing a discontinuous switch from the high to the low growth equilibrium, i.e. a growth collapse. Additionally, we have illustrated the comparative statics of this equilibrium. Calvo (2003) extensively explains how the growth collapse automatically translates into a sudden stop of capital flows.

6 Conclusion

In the present work we have added the possibility of coordination failure between investors as a factor triggering a sudden stop.

The main findings of the present work are, that, with the help of the theory of global games, we can determine a unique threshold equilibrium

¹⁸cf. Morris and Shin (2004)

¹⁹For an extensive analysis of transparency cf. Heinemann and Illing (2002).

in a set up where beforehand multiplicity prevailed. By comparative static analysis of this unique equilibrium we then find three results: The probability of a sudden stop decreases with technological progress. It increases with a higher international interest rate and with noisier signals. With regard to the discussion on internal versus external factors, that attract capital to emerging markets, we find, that with increasing international interest rate, the scope of policy action, preventing a sudden stop, is reduced. In contrast, with technological progress, government gains scope for its actions. Thus in terms of the discussion regarding pull and push factors of capital flows, we find, that the relative importance of those factors vary.

It has to be mentioned, that in the present work, we have not included considerations about default and thereby credit frictions. Furthermore, we have not extended the non-monetary model to one with money. These two extensions can be found in Calvo (2003). In the mentioned paper Calvo also shows, that if the crisis is foreseen, i.e. if the critical value of government debt is exceeded in the future only, a growth collapse and also a sudden stop will take place at this future foreseeable point in time. The introduction of infinitely many firms do not alter these considerations. Banking crises however cannot be rationalized within the current framework.

There are two worthwhile extensions of the model. First, it would be interesting to add the assumption of public information about the level of

the debt to the assumption of private information of each investor. So far we have assumed, that agents base their decision on their personal interpretation of publicly available information, that is each investor does not know, how the other investors interpret the available information. However, following Morris and Shin (2004), Metz (2002) and Hellwig (2002), it would be interesting to analyze the effect of the interaction of public information, that is common knowledge to all players and private information on the coordination of private investors. Second, it would be insightful to analyze the distinction between domestic and foreign investors: How would the probability of a sudden stop be influenced if the signals of domestic and foreign investors are differently dispersed around the true value of the debt? Are economies with investors that differ with regard to the precision of their information more prone to crisis than economies with homogenous and only domestic investors?

The next step in our research agenda will be to test the hypothesis of this paper empirically. Especially, the empirical analysis of the effect of uncertainty about the fundamentals and its effect on the occurrence of sudden stops would be a contribution to the empirical literature. The effect of uncertainty has so far only been analyzed in the context of currency crises (cf. Prati and Sbracia (2002)) and sudden stops seem to be a natural application as well.

References

- Arellano, C. and Mendoza, E. (2003). *Dynamic Macroeconomic Analysis*, chapter Credit Frictions and 'Sudden Stops' in Small Open Economies: An Equilibrium Business Cycle Framework for Emerging Markets Crises. Cambridge University Press.
- Calvo, G. (1994). *New Theories in Growth and Development*, chapter Growth, Debt and Economic Transformation: The Capital Flight Problem. Palgrave Macmillan.
- Calvo, G. (1998). Capital flows and capital-market crises: The simple economics of sudden stops. *Journal of Applied Economics*, 1(1):35–54.
- Calvo, G. (2003). Explaining sudden stop, growth collapse and bop crises - the case of distortionary output taxes. *IMF Staff papers*.
- Calvo, G., Leiderman, L., and Reinhart, C. (1993). Capital inflows to latin america: The role of external factors. *IMF Staff Papers*, 40:108–51.
- Calvo, G., Leiderman, L., and Reinhart, C. (1996). Inflows of capital to developing countries in the 1990s. *The Journal of Economic Perspectives*, 10:123–139.
- Calvo, G. and Reinhart, C. (2000). When capital flows come to a sudden

- stop: Consequences and policy. *in Kenen, P. and Swoboda, A. (eds.) Reforming the international monetary and financial system*, Washington DC(International Monetary Fund).
- Caprio, G. and Klingebiel, D. (1999). Episodes of systemic and borderline financial crises. *working paper and database*, Worldbank website:periodically updated.
- Carlsson, H. and van Damme, E. (1993). Global games and equilibrium selection. *Econometrica*, LXI(5):989–1018.
- Diaz-Alejandro, C. (1983). *Financial Policies and the World Capital Market: The Problem of Latin American Countries*, chapter Stories of the 1930s to 1980s, pages 5–35. University of Chicago Press.
- Doenges, J. and Heinemann, F. (2001). Competition for order flow as a coordination game. *Goethe-Universitaet Frankfurt Working Paper*, 64.
- Eaton, J. (1987). Public debt guarantees and private capital flight. *World Bank Economic Review*, January:337–95.
- Fernandez-Arias, E. (1996). The new wave of private capital inflows: Push or pull? *Journal of Development Economics*, 48:389–418.
- Heinemann, F. (2001). Private information als mittel zur vermeidung multipler gleichgewichte. *Working Paper*.

- Heinemann, F. and Illing, G. (2002). Speculative attacks: unique equilibrium and transparency. *Journal of International Economics*, 58:429–450.
- Hellwig, C. (2002). Public information, private information, and the multiplicity of equilibria in coordination games. *Journal of Economic Theory*, 107:191–222.
- Hutchison, M. and Noy, I. (2002). Sudden stops and the mexican wave: Currency crises, capital flow reversals and output loss in emerging markets. *EPRU Working Paper Series 1999*, 02-12.
- Metz, C. (2002). Public and private information in self-fulfilling currency crises. *Journal of Economics*, 76:65–85.
- Milgrom, P. and Roberts, J. (1990). Rationalizability, learning and equilibrium in games with strategic complementarities. *Econometrica*, 58:1255–1278.
- Montiel, P. and Reinhart, C. (1999). Do capital controls and macroeconomic policies influence the volume and composition of capital flows? evidence from the 1990s. *Journal of International Money and Finance*, 18:619–635.
- Morris, S. and Shin, H. (1998). Unique equilibrium in a model of self-fulfilling currency attacks. *The American Economic Review*, 88(No. 3).

Morris, S. and Shin, H. (2004). Coordination risk and the price of debt.

European Economic Review, 48:133–153.

Prati, A. and Sbracia, M. (2002). Currency crises and uncertainty about fundamentals. *IMF Working Paper*, 3.

7 Appendix

7.1 Value of the firm

$$\begin{aligned}
 V^i &= \int_0^\infty [\alpha(1 - \tau) - z_t^i] e^{-\int_0^t (r - z_s^i) ds} dt \\
 \Leftrightarrow V^i &= \int_0^\infty [\alpha(1 - \tau) - z^i] e^{-(r - z^i)t} dt \\
 &= [\alpha(1 - \tau) - z^i] \int_0^\infty e^{-(r - z^i)t} dt
 \end{aligned}$$

assuming $r > z$

$$= [\alpha(1 - \tau) - z^i] \left[\frac{e^{-(r - z^i)t}}{-(r - z^i)} \right]_0^\infty = [\alpha(1 - \tau) - z^i] \frac{1}{(r - z^i)}$$

7.2 unique equilibrium

7.2.1 unique D^*

In the setup with infinitely many, identical players the probability that all other players receive a signal that is below D^* is equal to the proportion of

players who received such a signal. Given that the signal of player i equals D^* and due to the fact, that the signal is uniformly distributed around the true value of the debt in an epsilon surrounding, this proportion can be calculated as:

$$prop(D^j < D^* | D^i = D^*) = \frac{D^* - (D - \epsilon)}{2\epsilon}$$

Given that the Signal of player i is D^* and the posterior distribution is uniform the expected value in equation (18) can then be expressed as the following integral on the true value of the debt over the interval from $D^* - \epsilon$ to $D^* + \epsilon$:

$$\begin{aligned} & \int_{D^* - \epsilon}^{D^* + \epsilon} \frac{1}{2\epsilon} D \frac{D^* - D + \epsilon}{2\epsilon} dD \\ &= \frac{1}{4\epsilon^2} \left[\frac{1}{2} D^2 D^* - \frac{1}{3} D^3 + \frac{1}{2} \epsilon D^2 \right]_{D^* - \epsilon}^{D^* + \epsilon} \end{aligned}$$

The above expression simplifies to:

$$\frac{D^*}{2} - \frac{\epsilon}{6}$$

With this result, we can simplify equation (18) to become:

$$\tilde{U}(D^*) = \bar{z}^i * \frac{\alpha - r - rD^* + \bar{z}(\frac{D^*}{2} - \frac{\epsilon}{6})}{(r - \bar{z}^i)r} = 0$$

Solving for D^* delivers the unique value:

$$D^* = \frac{\alpha - r - \frac{\epsilon}{6}\bar{z}}{(r - \frac{1}{2}\bar{z})}$$

q.e.d.

7.2.2 monotonicity of $\tilde{U}$ in D^1

The monotonicity of $\tilde{U}$ in D^1 is a necessary condition for the iterated elimination of dominated strategies to work and to make sure, that there are not several values for which equation 18 holds.

The denominator of:

$$\tilde{U}(D^i, I_{D^k}) = \bar{z}^i * \frac{\alpha - r - rD^i + \bar{z}E(D * \text{prob}(D^j < D^k)|D^i)}{(r - \bar{z}^i)r} \quad (25)$$

is independent of the signal D^i and must always be positive, because we restricted $\bar{z}^i$ to be smaller than r , so that the considered economy cannot outgrow the world market in size over time. So we can restrict our analysis to the elements of the numerator.

It is clear that the term

$$\frac{\partial(-\bar{z}^i r D^i)}{\partial D^i} < 0$$

is strictly decreasing in D^i . It is more difficult to show this for the term $E(D * \text{prob}(D^j < D^k|D^i))$. However we know, that $E(D^j|D^i) = D^i$ and that D^j is triangularly distributed in a $2 * \epsilon$ surrounding of D^i . Therefore we get

$$\frac{\partial \text{prob}(D^j < D^k|D^i)}{\partial D^i} \begin{cases} = 0 & \text{if } D^k < D^i - 2 * \epsilon \text{ and } D^k > D^i + 2 * \epsilon \\ < 0 & \text{if } D^i - 2 * \epsilon \leq D^k \leq D^i + 2 * \epsilon \end{cases}$$

Hence this term is weakly decreasing in D^i . This must then also be true for the expected value, we are interested in.

Adding the two terms that are dependent on D^i , we find, that $\tilde{U}(D^i, I_{D^k})$ is strictly monotonically decreasing in D^i .

q.e.d.

As we were able to execute the two steps successfully, we can conclude, that there exists a unique equilibrium.

7.3 List of Headline Crises

Focal crises - Headline crises - (large IMF packages, defaults, currency crises)

measures

				Output	Private Net Flows on Debt $\frac{\$}{\text{billion}}$	Net Private Capital Flows		Net Private Capital Flows plus Net Errors and Omissions		
Country	year	What defined crises	IMF-supported Programs/Aid packages	$\frac{((\text{GDP} - \text{GDP}_{-1})}{\text{GDP}_{-1}}) \times 100$	$\frac{((\text{GDP} + 1 - \text{GDP}_{-1})}{\text{GDP}_{-1}}) \times 100$	Global Development Finance $\frac{\$}{\text{billion}}$	WEO $\frac{\$}{\text{billion}}$	BOP YB $\frac{\$}{\text{billion}}$	WEO $\frac{\$}{\text{billion}}$	BOP YB $\frac{\$}{\text{billion}}$
the 70s										
Peru	1978	sovereign default, Currency crisis (FR), no banking crises	1978: IMF stabilization program+ multilateral rescheduling with official and private creditors	0.08	5.68	-6.89	-4.75	-5.93	-4.32	-4.77
Turkey	1978	sovereign default, no currency crises, fall in Central bank reserves, 1982-85 Systemic banking crisis		2.83	1.93	-5.89	-2.65	-1.61	-2.88	-2.01
United Kingdom	1974-76	Currency Crisis in 1976 (ERW), Borderline and smaller banking crisis		-1.70	-2.38		5.08	2.24	5.08	2.25
Zaire	1978	Sovereign default since 1976, Enormous amounts of external debt lead to Paris Club reschedulings in 1979 as well as 1981 and with a syndicate of commercial banks in 1980, Currency Crisis in 1979 (MR and BP), 1980s Systemic banking crisis		-5.30	-5.02	-0.21	-6.86		-6.69	
crises countries 80s										
Argentina 1982-88	1982	sovereign default, Currency Crises in 1981 (MR1, FR, GKR) and 82 (FR, BP, GKR), 1980-82 Systemic banking crisis, 1989-90 Systemic banking crisis, hyperinflation		-3.15	0.47	0.24	0.18	-0.11	0.16	-0.23
Bolivia	1980	sovereign default in 1980, hyperinflation, Spring 1984 suspension of interest payments to commercial banks, Currency Crises in 1980 (MR2), 1982 (MR, FR, BP, GKR), 83 (FR, BP, GKR), 84 (FR) and 85 (FR, BP, GKR), 1986-88 Systemic banking crisis		0.61	1.54	-10.13	-12.29	-2.40	-19.60	-14.72
Brazil	1982	sovereign default 1983, Currency Crisis in 1982 (BP) and 83 (FR, BP, GKR), no banking crisis	Brady Plan: Brazil Parallel Financing agreement, terms announced Sep 1988	-4.36	-8.63	0.24	-0.69	-0.41	-1.12	-0.38
Bulgaria 1990	1989	No sovereign default but during second half of 80s build up of large external debt in order to finance enlarging current account deficit. no data on currency crises available, but exhaustion of foreign reserves. 1995-97 Systemic banking crisis	Brady Plan: Bulgaria Brady, terms announced Mar 1994	-0.50	-9.55	0.68	-0.30	-3.88	0.49	-2.01
Chile (Cline p. 287)	1982	Sovereign default in 1983, Currency Crises in 1982 (MR, FR, GKR) and 83 (FR), 1981-86 Systemic banking crisis		-13.42	-16.44	-5.50	-9.57	-10.03	-9.95	-10.49
China	1990	Currency Crises 1990 (MR), 1991 Systemic banking crisis		3.80	13.35	1.14	-1.74	-0.21	-2.46	-0.95
Colombia (Cline p. 287)	1983	No Sovereign default, Currency Crises in 1983 (GKR) 1985 (BP and GKR), 1982-87 Systemic banking crisis		1.57	4.98	-1.88	-3.21	-2.56	-3.72	-3.33
Costa Rica	1981	Sovereign default, Severe balance of payment crisis, Currency Crises in 1981 (MR and FR), no banking crisis	Brady plan: Costa Rica Brady terms announced May 1990	0.80	-6.25	-8.41	-7.07	-10.07	-9.32	-7.19
Cote d'Ivoire	1984	Sovereign default, no Currency Crisis, Systemic banking crisis from 1988-91	Brady plan concluded in 1997	-2.00	1.55	0.38	-25.75	-13.32	-20.19	-12.80
Ecuador	1982	Sovereign default, Currency Crises in 1983 (MR2), 84 (MR1) and 86 (MR, FR), 1980- 83 Systemic banking crisis	Brady plan:Ecuador Brady, terms announced May 1994	1.20	-1.63	-7.93	0.93	7.40	3.46	2.30
Korea (Sachs, p. 12)	1980	No Sovereign default, but in 1981world's fourth largest debtor country. Currency Crisis in 1980 (MR, BP and GKR), Doubling of inflation from 14.4 % in 1978 to 28.7 % in 1980.		-2.09	4.24	-0.11	0.77	1.99	6.74	1.83
Jordan	1989	Sovereign default on loans to commercial banks, Currency Crisis (MR1, FR, BP), Non systemic banking crisis	Brady Plan: Jordan Brady, terms announced in July 1993	-13.45	-7.29	24.74	-41.37	-3.59	-34.87	-5.61

Focal crises - Headline crises - (large IMF packages, defaults, currency crises)

Focal crises - Headline crises - (large IMF packages, defaults, currency crises)					measures					
			Output	Private Net Flows on Debt 5/	Net Private Capital Flows	Net Private Capital Flows plus Net Errors and Omissions				
Country	year	What defined crises	IMF-supported Programs/Aid packages	(GDP _t - GDP _{t-1}) /GDP _{t-1} *100	((GDP _{t+1} - GDP _t)/ GDP _t)*100,	Global Development Finance 2/	WEO 3/	BOP YB 4/	WEO 3/	BOP YB 4/
the 90s till present										
		Contagion from Mexican crisis, background currency board without deposit insurance scheme and without lender of last resort: withdrawal of bank deposits, significant loss of central bank's gross reserves, liquidity crunch, surge in interest rates, output contraction, Systemic banking crisis	X / EFF	3.85	7.79	5.36	-1.16	-1.88	-1.91	-2.38
Argentina	1995	sovereign default, no data on currency crisis, 2001-present		2.10	5.27		-7.19	-4.28	-5.02	-5.06
Argentina	2001-2	Systemic banking crisis								
		No sovereign default, Currency crises in 1999 (MR1), substantial current account deficit, surge of interest rates, outflow of capital, Output contraction, 1994-9	X/ SBA/ SRF, new arrangement, 12/2/98, X / SBA/SRF, new arrangement, 9/14/01,	0.13	0.92	0.07	0.41	0.82	0.31	0.85
Brazil	1998	Systemic banking crisis								
		El Nino crisis, default on external and internal debt, Currency Crises in 1999 (MR1), 1998-present								
Ecuador	1999	Systemic banking crisis		-6.30	-3.67	-4.26	-16.63	-13.47	-14.09	-15.36
		Currency Crises: Denmark 93 (GKR), Finland 92 (GKR, ERW), Ireland 92 (ERW), Italy 92 (ERW), Portugal 93 (MR1), Spain 92 (GKR) and 93 (GKR), Sweden 92 (ERW), UK 92 (ERW)		0.00	0.00					
ERM	1992/1993									
		No sovereign default, Currency Crisis in 1991 (GKR)								
Finland	1991-94	and 92 (GKR, ERW), Systemic banking crisis		-6.26	-9.37		-3.20	-5.88	-1.55	-4.19
		no sovereign default, consequence of unresolved capital account crisis, important short-term private sector external debt, depreciation, hyperinflation, runs on deposits, collapse of corporate balance sheets, sharp economic contraction, Currency Crisis in 1997 (MR2, BP, GKR), 1997-present	X/ SBA, new arrangement, 11/5/97	4.54	-9.18	-2.92	-0.90	-3.71	0.95	-5.46
Indonesia	1997-98	BP, GKR), 1997-present								
		No sovereign default, but high level of short term private foreign debt, Currency Crisis in 1997 (MR2, FR, BP, GKR) and 98 (MR1)	X/ SBA/SRF, new arrangement, 12/4/97	5.01	-2.01	-6.32	-8.52	-4.54	-9.70	-5.72
Korea	1997-8	FR, BP, GKR) and 98 (MR1)								
		Tequila crisis. No sovereign default, Currency Crisis in 1994 (BP, GKR) and 95 (MR), 1994-97	X / SBA, new arrangement, 2/1/95	-6.17	-1.33	0.10	-4.09	-4.32	-2.67	-2.90
Mexico	1994-5	banking crisis								
		No sovereign default, interest rate surge, real GDP contraction, Currency Crisis in 1997 (FR, BP), 1998		7.32	-0.57	1.39	-7.82	-7.17	-7.55	-4.83
Malaysia	1997-8	(MR1), 1997-present								
		No sovereign default, currency crisis in 1986 (ERW),		0.90	2.92		-2.69	-2.94	-2.85	-3.10
Norway 1987-93	1989	Systemic banking crisis								
		Sovereign default, Eurobond exchange, no Currency		3.96	7.57	-0.72	-1.06	0.97	-0.49	0.57
Pakistan	1999-2000	Crisis in 1999, 2000 n.a., no data on banking crisis								
		No sovereign default, Currency Crisis in 1997 (FR, GKR), 1998-present	X/ EFF	5.19	4.58	2.55	-4.83	-4.82	-7.60	-7.54
Phillippines	1997	GKR), 1998-present								
		Sovereign default 1998-99, interest rate surge, Currency Crises in 1998 (GS), 1998-9	EFF/SFR/CCFF, Augmentation and Extension, 7/20/98	-4.90	0.24	2.90	0.26	1.46	-0.51	0.47
Russia	1998	banking crisis								
		No sovereign default, Currency Crisis 1992 (GKR),		-1.11	-2.83		-4.02	-9.30	-4.02	-4.67
Sweden	1991	Systemic banking crisis								
		No sovereign default, but roll over of short term debt stopped, Currency Crisis in 1997(MR2, FR, BP, GKR), 1997-present	X/ SBA, new arrangement, 8/20/97	-1.37	-11.74	-7.11	-18.42	-12.75	-18.54	-13.05
Thailand	1997-8	GKR), 1997-present								
		No sovereign default, interest rate surge, Currency Crisis in 1994 (BP, GKR), Non systemic banking								
Turkey	1994	crisis	X/ SBA	-4.97	1.57	-9.47	-4.45	-6.19	-4.45	-4.23
		No sovereign default, no data on currency crisis	X / SBA/SRF, augmentation, 5/15/01, SBA, new arrangement, 2/4/02	7.36	-0.69	1.18	-1.33	3.75	-1.33	1.53
Turkey	2000	available, 2000-present								

Figure 3: Headline Crises from the 1970-2000