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GOVERNMENT GUARANTEES, INVESTMENT, AND VULNERABILITY TO FINANCIAL CRISES

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ABSTRACT

Government Guarantees, Investment And Vulnerability To Financial Crises *

This Paper presents a new model of the East Asian crisis that combines three elements – multiple equilibria, investment collapse, and moral hazard – in a single simple account. We locate the causes of the crisis in poor financial regulation, highly-geared financial institutions, and implicit guarantees to the financial sector that create moral hazard. The model has a unique long-run equilibrium with over-investment as a result of the guarantees. But in the short run, in which the capital stock is fixed, there may be multiple equilibria. If foreign banks regard lending as low-risk, then it is. But if they regard lending as high-risk and charge a higher interest rate, then the costs of honouring guarantees rises, making the lending high-risk and the risk premium self-justifying. A crisis occurs with a switch to this second equilibrium in which the government is forced to renege on its guarantees; the effect is a reversal of foreign capital flows. Whether multiple equilibria exist – and hence whether the economy is vulnerable to a crisis – depends critically on the extent of capital accumulation and the mix between debt and equity financing.

JEL Classification: E44, F34, O16
Keywords: East Asian economic crisis, financial crisis, multiple equilibrium and over-investment

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Submitted 17 October 2000

NON-TECHNICAL SUMMARY

Most observers are now agreed with Krugman (1999) that the East Asian financial crisis did not just result from a worsening of fundamentals, as in the original Krugman (1998) 'What happened to Asia?' paper. It also involved a problem of panic and collapse, to do with a shift from a 'good' equilibrium to a 'bad' one (Radelet and Sachs, 1998). Most, too, are agreed that a 'third generation' model is needed which puts interaction between the financial system and a collapse of investment centre-stage. Yet many also believe that what went wrong in the financial system contained an important element of moral hazard, along the 'crony capitalism' lines set out in Krugman's original paper.

This Paper combines these three elements – multiple equilibria, investment collapse, and moral hazard – in a single simple account of the East Asian crisis. To our knowledge these elements have not been formally combined before in accounts of the crisis. They are as follows.

First, there are now a whole raft of multiple equilibrium models available with which to study the crisis. The present Paper uses a basic mechanism from Calvo (1988) to generate multiple equilibria. In particular, a high interest rate (due to a high risk of default perceived by international creditors) forces the government either to raise taxes – to pay its obligations – or to default. If taxes are more costly then default is optimal, which rationalizes the high-risk premium. On the other hand there is always another equilibrium in which the risk perceived is low and hence the interest rate charged is low. In this event taxes are low, which enables the government to cover its commitments. Hence there is no default, which rationalizes the low-risk premium charged. The difference between what we do and what Calvo did is that in his paper the government's obligations come from interest on its *actually existing* stock of public debt, and the multiple equilibrium problem can arise if this is large; here the government's obligations come from *contingent* liabilities to the financial system, and the multiple equilibrium problem can arise if these are large. We present an account of what can make these contingent liabilities large enough to make the economy vulnerable to crisis.

Second, there is now an important strand of literature which locates the East Asian crisis in the interrelationship between the financial system and investment. Krugman (1999) shows that in a boom the real debt burden of firms declines, leading to a high collateral of firms and high investment, which is why there is a boom. Conversely, when there is a slump the real debt burden grows, leading to low collateral, low investment, and tendencies to slump. Aghion et al. (1999) present a dynamic version of a similar story. Our focus is different. We concentrate not on the changing value of firm collateral, but on the evolution of the solvency of bank-based financial systems to which the government provides financial guarantees; it is these guarantees which

can give rise to the possibility, already discussed, of a high level of contingent government liabilities.

Third, we add the moral hazard story from Krugman's description of Pangloss over-investment in his original paper. In the expectation of bail-out, firms invest beyond the point at which the expected marginal product of capital equals the interest rate, and government guarantees make up the difference. In the present Paper we show how this over-investment can cause the government's contingent liabilities to grow beyond the point where the government can honour them for sure, leading to a vulnerability to the high interest rate equilibrium already described. We also show that adequate equity financing can mitigate or remove this problem. We thus explore the combination of guarantees, giving rise to over-investment and an over-reliance on debt financing, as creating the vulnerability to financial crisis.

We combine these three elements in the following way. We analyse a series of static, one-shot games played over time, in which the returns to investment are uncertain. There are Krugman-style investors – financial intermediaries – who employ all capital used in production and finance this in part by borrowing from foreign banks. There is an unregulated financial system in which financial intermediaries can default on loans at no cost if there is a bad outcome. There is a government which implicitly guarantees the loans that financial intermediaries receive from abroad. Without guarantees investment is efficient, even though the financial sector is unregulated, because foreign banks simply raise the interest rate to cover the risk of financial intermediaries defaulting. But with credible guarantees the interest rate is kept low and this causes an inefficiently high level of investment. If the guarantees are fully credible the interest rate is pushed down to the risk-free world rate, and capital is accumulated; the economy moves towards an equilibrium with an inefficiently high capital stock.

In our model the government has a limited willingness to pay up on its guarantees if there is a bad outcome. As a result its guarantees may lack credibility. We model the government's problem by assuming it pays a one-off political cost if it ever reneges. The choice for the government is between paying this cost or the taxation cost of bailing out the financial intermediaries.

We show that there is a unique long run equilibrium for the economy, in which the interest rate is low and there is over-investment. There is no high interest rate long-run equilibrium, because high interest rates would mean that less capital would be accumulated and that, in turn, would mean a smaller stock of guarantees outstanding. As a result, even if there were a bad productivity shock to the economy, the government could afford to honour its guarantees, thus removing any rationale for high interest rates. If the cost of reneging is high, which we assume, then the unique long-run equilibrium will be one in which the government guarantee is fully credible and so foreign banks lend to financial intermediaries at the risk-free world interest rate. Capital is

accumulated over time towards this long-run equilibrium with over-investment occurring along the lines of Krugman's Pangloss story.

We show, however, that if there is inflexibility of the capital stock in the short run, due, say, to adjustment costs, then multiple equilibria may exist in the model when capital accumulation has passed a certain point. In the low interest rate equilibrium, if there is a bad productivity outcome, the government can afford to honour its stock of guarantees, even though the large stock of capital means that the stock of guarantees is large. In the high interest rate (or 'collapse') equilibrium, foreign banks believe there is a range of productivity shocks that will force the government to renege and so they raise the interest rate. But if they raise the interest rate sufficiently it might be that the government has no choice but to renege, even following a good productivity shock, and so the expectation is self-fulfilling. This leads to the possibility of financial crisis. Whether the economy is vulnerable to crisis depends critically on both the extent of capital accumulation and the mix between debt and equity financing. If the debt-to-equity ratio is low enough, the collapse equilibrium does not exist, and so the economy is not vulnerable to financial crisis.

1. Introduction

Most observers are now agreed with Krugman (1999) that the East Asian financial crisis did not just result from a worsening of fundamentals, as in the original Krugman (1998) 'What happened to Asia?' paper. It also involved a problem of panic and collapse, to do with a shift from a 'good' equilibrium to a 'bad' one (Radelet and Sachs, 1998). Most, too, are agreed that a 'third generation' model is needed which puts interaction between the financial system and a collapse of investment at centre-stage (Krugman, 1999, Aghion *et. al.* 1999). Yet many also believe that what went wrong in the financial system contained an important element of moral hazard, along the 'crony capitalism' lines set out in Krugman's original paper (Krugman, 1998).

This paper combines these three elements – multiple equilibria, investment collapse, and moral hazard – in a single simple account of the East Asian crisis. To our knowledge these elements have not been formally combined before in accounts of the crisis. In more detail they are as follows.

First, there are now a whole raft of multiple equilibrium models available with which to study the crisis. (For another example see Masson, 1999, and for a discussion of the implications of these models see Fischer, 1999.) The present paper uses a basic mechanism from an early paper by Calvo (1988) to generate multiple equilibria. In particular, a high interest rate (due to a high risk of default perceived by international creditors) forces the government either to raise taxes – to pay its obligations – or to default. If taxes are more costly then default is optimal, which rationalises the high risk premium. On the other hand there is always another equilibrium in which the risk perceived is low and hence the interest rate charged is low. In this event taxes are low, which enables the government to cover its commitments. Hence there is no default, which rationalises the low risk premium charged. The difference between what we do and what Calvo did is that in his paper the government's obligations come from interest on its *actually existing* stock of public debt, and the multiple equilibrium problem can arise if this is large; here the government's obligations come from *contingent* liabilities to the financial system, and the multiple equilibrium problem can arise if these are large.[1] We

[1] The head of Paribas Asia Equity, quoted in the *Financial Times*, 12/1/98, described what happened in Thailand as follows: '… the Bank of Thailand acting as lender of last resort … created a huge market distortion;

present an account of what can make these contingent liabilities large enough to make the economy vulnerable to crisis.

Second, there is now an important strand of literature which locates the East Asian crisis in the interrelationship between the financial system and investment. Krugman (1999) shows that in a boom the real debt burden of firms declines, leading to a high collateral of firms and high investment, which is why there is a boom. Conversely, when there is a slump the real debt burden grows, leading to low collateral, low investment, and tendencies to slump. Aghion *et. al.* (1999) presents a dynamic version of a similar story. Our focus is different. We concentrate not on the changing value of firm collateral, but on the evolution of the solvency of bank-based financial systems to which the government provides financial guarantees; it is these guarantees which can give rise to the possibility, already discussed, of a high level of contingent government liabilities.

Third, we add the moral hazard story from Krugman's description of Pangloss over-investment in his original paper. In the expectation of bailout, firms invest beyond the point at which the expected marginal product of capital equals the interest rate, and government guarantees make up the difference. However, as presented, Krugman's story was not necessarily a story of crisis: if taxpayers can be persuaded to go on paying for bailouts then such a set-up can go on repeating itself. It certainly does not provide the basis for a story of panic and collapse. In the present paper we show how this over-investment can cause the government's contingent liabilities to grow beyond the point where the government can honour them for sure, leading to a vulnerability to the high interest rate equilibrium already described.[2] We also show that adequate equity financing can mitigate or remove this problem. We thus explore the combination of guarantees, giving rise to over-investment, and an over-reliance on debt financing, as creating the vulnerability to financial crisis.

We combine these three elements in the following way. We analyse a series of static, one-shot

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there was no significant risk premium. It was all sovereign risk. When the Bank of Thailand decided it could not or would not act as a lender of last resort, the risk premium went through the roof – all the way to infinity' (head of Paribas Asia Equity, quoted in the *Financial Times*, 12/1/98)

[2] Our approach thus provides a formal model of the situation described informally by the IMF as follows: '[the problem was] rooted mainly in financial sector fragilities, stemming in part from weaknesses in governance in the corporate, financial, and government sectors, which made these economies increasingly vulnerable to changes in market sentiment, a deteriorating external situation, and contagion.' (Lane *et al*, 1999, p.1)

games played over time. Since we are modelling the effects of *ex ante* guarantees we need to include stochastic shocks to the environment, so that *ex post* outcomes are uncertain when decisions are taken. There are Krugman-style investors – financial intermediaries – who employ all capital used in production and finance this in part by borrowing from foreign banks. There is an unregulated financial system in which financial intermediaries can default on loans at no cost, if there is a bad outcome. There is a government which implicitly guarantees the loans that financial intermediaries receive from abroad. Without guarantees investment is efficient, even though the financial sector is unregulated, because foreign banks simply raise the interest rate to cover the risk of financial intermediaries defaulting. But with credible guarantees the interest rate is kept low and this causes an inefficiently high level of investment. If the guarantees are fully credible the interest rate is pushed down to the risk-free world rate, and capital is accumulated; the economy moves towards an equilibrium with an inefficiently high capital stock.

In our model, as in the Calvo paper (see also Dooley, 2000), the government has a limited willingness to pay up on its guarantees if there is a bad outcome. As a result its guarantees may lack credibility. We model the government's problem by assuming it pays a one-off political cost if it ever reneges. The choice for the government is between paying this cost or the taxation cost of bailing out the financial intermediaries.

We show that there is a unique long run equilibrium for the economy, in which the interest rate is low and there is over-investment. There is no high-interest rate long-run equilibrium, because high interest rates would mean that less capital would be accumulated and that, in turn, would mean a smaller stock of guarantees outstanding. As a result, even if there were a bad productivity shock to the economy, the government could afford to honour its guarantees, thus removing any rationale for high interest rates. If the cost of reneging is high, which we assume, then the unique long-run equilibrium will be one in which the government guarantee is fully credible and so foreign banks lend to financial intermediaries at the risk-free world interest rate. Capital is accumulated over time towards this long-run equilibrium with over-investment occurring along the lines of Krugman's Pangloss story.

However, what we show is that if there is inflexibility of the capital stock in the short run, due, say, to adjustment costs, then multiple equilibria may exist in the model when capital

accumulation has passed a certain point. In the low interest rate equilibrium, if there is a bad productivity outcome, the government can afford to honour its stock of guarantees, even although the large stock of capital means that the stock of guarantees is large. In the high interest rate (or 'collapse') equilibrium, foreign banks believe there is a range of productivity shocks that will force the government to renege and so they raise the interest rate. But if they raise the interest rate sufficiently it might be that the government has no choice but to renege, even following a good productivity shock, and so the expectation is self-fulfilling. This leads to the possibility of financial crisis.

Whether the economy is vulnerable to crisis depends critically on both the extent of capital accumulation and the mix between debt and equity financing. We show that vulnerability can be avoided, at least initially following the introduction of a guarantee, if capital investment is backed by sufficient equity. A lower debt-to-equity ratio has two important effects. First, the long-run equilibrium capital stock is kept low, even if the government guarantees loans, because capital investment must, on average, be sufficiently profitable to reward equity investors for the opportunity cost of their investment. A lower debt-to-equity ratio, therefore, means that the extent of moral-hazard induced over-investment is reduced. Second, equity provides a buffer against default, because equity investors are only a residual claimant on the returns to investment. Lending therefore becomes less risky.

If the debt-to-equity ratio is low enough, the collapse equilibrium does not exist, and so the economy is not vulnerable to financial crisis. We describe a helpful way of determining if this is the case: there is no collapse equilibrium if there is a finite market interest rate at which foreign banks would be willing to roll-over debt *without* a government guarantee. In this situation, if foreign banks believed that the government would renege then they would raise the interest rate to this finite market-determined level. But as the government *can* afford to honour the guarantee at this interest rate then expectation of reneging would not be validated. As a result there is no collapse equilibrium. Instead there is a unique equilibrium with a low interest rate and the government honours the guarantee for sure, and so the economy is not vulnerable to a financial crisis.

The remainder of the paper is set out as follows. In the next section we state the key assumptions of the model and we solve for the pre-guarantee equilibrium. In section 3 we

consider the effect of a government guarantee on the incentives of foreign banks and the conditions under which the government will honour the guarantee. In section 4 we outline the equilibria of the model in the long-run and the short-run. In section 5 we consider how this model can be used to explain financial crises, and in particular when and why an economy becomes vulnerable to financial crises. Section 6 concludes.

2. The Model

In this model there are three key groups: financial intermediaries who employ all capital used in the production of a single output; foreign banks who lend to financial intermediaries to finance investment; and the government which implicitly promises to guarantee the loans to financial intermediaries. We assume financial intermediaries and foreign banks act competitively. We assume that proportion z of investment is financed by borrowing from foreign banks, with the remainder financed by the equity stake of the owners of the financial intermediaries ($0 < z \leq 1$). This variable has a critical influence on incentives and consequently on whether the economy becomes vulnerable to a financial crisis. The implication is that by influencing this variable financial regulators could seek to prevent a vulnerability to crisis from arising.

In the absence of a guarantee financial intermediaries make debt repayments to foreign banks if they have the funds to do so. But if they have insufficient funds financial intermediaries can default. Limited liability means the owners of financial intermediaries lose their equity investment, but there are no additional costs (effectively we assume that bankruptcy costs are zero).

We assume there is a fixed supply of labour that is fully employed and which receives its marginal product each period. We also assume there are constant returns to scale in the labour and capital inputs in the production process. Financial intermediaries choose the capital to labour ratio, k, but because of adjustment costs this variable is held fixed in the short run. For analytic convenience we assume output per worker, y, is a quadratic function of k:

$$y = (\alpha + u)k - \beta k^2 \qquad (1)$$

where $u \sim U[0,1]$ is a productivity shock, realised after investment decisions are made, and α and β are technology parameters.

2.1. The Pre-Guarantee Equilibrium

In this section we derive the equilibrium without a guarantee, as a preliminary to looking at the effects of introducing one. We seek short-run equilibria for the interest rate and long-run equilibria for the interest rate and the capital-to-labour ratio.

Short Run

In the short run, for a given *k*, the interest rate at which foreign banks are prepared to lend to financial intermediaries is interrelated with the probability of default on loans. We now investigate this interrelationship.

In each period capital is invested and emerges as output with a one period delay. At the end of the period, if the realisation of the productivity shock, *u*, is sufficiently high, then the loan to foreign banks is serviced in full and the value of the equity invested by the owners of the financial intermediaries is given by output plus capital, less labour costs and the loan repayment.[3] If the productivity shock is not high enough for this then financial intermediaries default and the value of equity invested is zero. As labour is paid its marginal product, βk^2, we may write the value of equity invested per unit of labour input, v^I, as:

$$\begin{aligned} v^I &= y + k - \beta k^2 - z(1+r)k \qquad \text{when} \quad y > \beta k^2 - kz(1+r)k \\ &= 0 \qquad\qquad\qquad\qquad\qquad\quad \text{otherwise} \end{aligned}$$

Substituting for (1), after some manipulation we get:

$$\begin{aligned} v^I &= [u - m]k \qquad \text{when} \quad u > m \\ &= 0 \qquad\qquad\quad \text{otherwise} \end{aligned} \tag{2}$$

for $$m = -\alpha + 2\beta k - 1 + z(1+r) \tag{3}$$

Because *u* has a rectangular distribution, *m* is not only equal to the level of shock below which default occurs, but is also equal to the probability of default (given *k*, *z* and *r*, and within the range $0 \le m \le 1$). From (3) an increase in the interest rate at which foreign banks lend will

[3] For simplicity we assume there is no depreciation.

increase the probability of default. This is plotted as the upward sloping line $m(r,k)$ in figure 1.

We assume foreign banks are risk neutral. They receive the full debt repayment when financial intermediaries do not default ($u \geq m$) and – in the absence of any guarantee – have only a residual claim on output if they do ($u < m$). Note that if $m > 1$ financial intermediaries will default for sure. In the event of default, the value of this residual claim is equal to the value of output plus the capital stock less the wage. Assuming $m \leq 1$, the expected repayment to foreign banks per unit of labour employed, Ev^B, is:

$$Ev^B = (1-m)(1+r)zk + \int_0^m (y + k - \beta k^2)du$$

Substituting for (1), after some manipulation we may write this as:

$$Ev^B = (1+r)zk - \int_0^m (m-u)kdu \qquad (4)$$

which has the interpretation that the expected repayment to the banks is equal to full repayment minus the shortfall in repayment integrated across that part of the shock distribution in which default takes place. Integrating gives:

$$Ev^B = (1+r)zk - m^2k/2$$

This has the obvious interpretation that the shortfall is equal to proportion *m* of shocks for which default takes place, times the average shortfall, $mk/2$, which occurs when it does. We can now derive the market interest rate as a function of *m*, by the condition that the expected repayment to risk-neutral foreign banks equals the guaranteed payment from investing zk at the risk-free world interest rate, r^*. Thus,

$$(1+r^*)zk = (1+r)zk - m^2k/2$$

which gives,

$$r = r^* + m^2/2z \qquad (5)$$

The interest rate set by foreign banks is thus a mark-up over the risk-free rate, r^*, the size of which depends on the probability of default, *m*, and the proportion, *z*, of investment financed by borrowing. Note, given the probability of default, that the risk premium is a *decreasing* function of *z*. This is because, given *m*, the expected repayment shortfall is $m^2k/2$; the higher is *z* the larger is the loan on which interest repayments in non-default states can compensate for this loss, and so the smaller the interest premium needs to be. The risk premium is

obviously zero when the probability of default is zero, and increases quadratically in this probability.[4]

We have thus shown that the probability of default depends on the interest rate and that the interest rate depends on the probability of default. In figure 1 below we show how these two relationships – (3) and (5) – can be used to pin down unique values for *r* and *m* as a function of the capital stock. Both functions are positively sloped and the equilibrium values are given by the unique point of intersection. Notice that in (5) *r* is independent of *k* (given *m*), but that in (3) *m* is increasing in *k*. This means that the equilibrium values of *r* and *m* are both increasing in *k*.

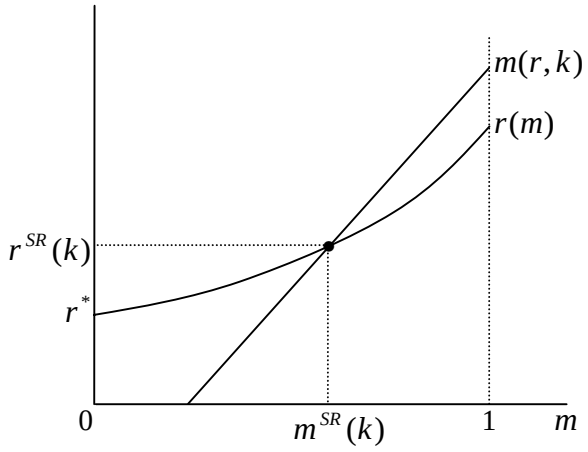

Figure 1

We can solve the simultaneous equations (3) and (5) to derive the short-run equilibrium values of both *r* and *m* as a function of a given *k*:

$$r^{SR} = \left(2 + \alpha - z - 2\beta k - \sqrt{3 + 2\alpha - 2z(1 + r^*) - 4\beta k}\right) / z \qquad (6)$$

$$m^{SR} = 1 - \sqrt{3 + 2\alpha - 2z(1 + r^*) - 4\beta k} \qquad (7)$$

These equilibrium values are defined providing the term under the square root sign in (6) and (7) is positive. If this is so then $m^{SR} < 1$. The condition for this is that:

$$k \le \bar{k} \qquad \text{where} \qquad \bar{k} = (3 + 2\alpha - 2z - 2zr^*) / 4\beta \qquad (8)$$

[4] Notice that for $z = 1$, as $m \to 1$ the risk premium does not tends to infinity but to the finite sum of 50 percent. This is because as $m \to 1$ we know that the expected payment shortfall is equal to half of capital, and so if the loan contact is one in which the interest rate is equal to 50 percent above the foreign interest rate then the expected return will still be equal to the foreign interest rate.

If (8) does not hold then the profitability of capital invested will have fallen to such an extent that financial intermediaries default for sure – even in the best state of the world – and there is no equilibrium interest rate at which foreign banks are willing to roll over the debt of financial intermediaries. Immediately below we show that without a government guarantee the capital-to-labour ratio is kept at or below $\bar{k}$ and (8) necessarily holds. In later sections of the paper we show that with a guarantee financial intermediaries may over-invest to such an extent that *k* rises above $\bar{k}$ – and that this is the boundary beyond which there can be multiple short-run equilibria and vulnerability to a financial crisis.

Long Run

In the long run the capital-to-labour ratio can be adjusted by financial intermediaries. We assume financial intermediaries are risk neutral and competitive. This means that the capital-to-labour ratio will rise until the expected value of equity investment equals the pay-off from the alternative of investing at the risk-free world interest rate, r^*. If the expected value of equity investment exceeded this level then financial intermediaries would have an incentive to employ additional capital, increasing both the capital-to-labour ratio and the wage, enabling them to attract scarce labour and achieve excess profits. Given zero bankruptcy costs, and assuming $0 \le m \le 1$, the expected value of equity investment is:

$$Ev^I = \int_m^1 (u-m)k\,du \tag{9}$$

Solving this integral we get:

$$Ev^I = (1-m)^2 k/2$$

which has the interpretation that the expected value of equity is equal to the probability that firms do not default, $1-m$, times the expected value of profit given that they do not default, $(1-m)k/2$. Equating this expected return to the alternative pay-off from investing at the world rate, $(1-z)(1+r^*)k$, we see that, over time, investment will continue until *k* reaches:

$$k = \left(2+\alpha - z(1+r) - q\right)/2\beta \tag{10}$$

for $$q = \sqrt{2(1-z)(1+r^*)} \tag{11}$$

Equations (6), (7), and (10) are simultaneous in *r*, *m*, and *k*. We can therefore solve for the long-run equilibrium if there is no guarantee: [5]

$$r^{LR} = r^* + (1-q)^2 / 2z \tag{12}$$

$$m^{LR} = 1-q \tag{13}$$

$$k^{LR} = \left(2\alpha + 1 - 2r^*\right)/(4\beta) \tag{14}$$

We may make four observations about this long run equilibrium.

First, the long run capital-to-labour ratio, k^{LR}, given by (14), is efficient. Calculation immediately shows that at k^{LR} the expected marginal product of capital equals the risk free world interest rate.

Second, k^{LR} is independent of the proportion of investment which is financed by borrowing, *z*.[6] The reason for this is that when *z* increases the risk from investment is transferred from one risk-neutral party to another, *i.e.* from financial intermediaries to foreign banks. This does not affect the return from investment and therefore the decision to invest; the only difference is that the interest rate and the probability of default rise to equate the expected pay-offs to each party in each case.

Third, by comparing (8) and (14) we can verify that $k^{LR} < \bar{k}$ for all $z < 1$.[7] This means that the probability of default is less than unity in long-run equilibrium, as long as there is some equity finance. The reason for this is that in the long-run *k* can be varied and optimally adjusted by financial intermediaries. Because they run the risk of making a loss, the investment level chosen by financial intermediaries will be such that they make profits in the best state of the world, so that on average they expect to make a return on equity equal to the world interest rate. This requires that $k < \bar{k}$.

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[5] We make the parameter restriction $\alpha > (2r^* - 1)/2$ so that the optimal capital stock, given by (14) below, is positive.

[6] This is consistent with the Modigliani and Miller (1958) proposition that a firm's value depends on its investment decisions rather than its capital structure.

[7] When $z = 1$, $k^{LR} = \bar{k}$.

Fourth, there is a level of z sufficiently low that financial intermediaries have such a large equity cushion that they never default, *i.e.* that $m^{LR} \leq 0$. (This comes from the assumption of a rectangular distribution.) The condition for $m^{LR} > 0$ is that:

$$z > \frac{1 + 2r^*}{2 + 2r^*} \tag{15}$$

We assume that this condition holds as otherwise financial intermediaries would never default and so a government guarantee of the kind to be discussed below would have no effect.

3. Implicit Government Guarantees

In this section we consider the outcome when the government (explicitly or implicitly) guarantees the debt of financial intermediaries. If the government honours the guarantee foreign banks receive the full debt repayment. Accordingly, the expectation that the government will honour the guarantee affects the interest rate at which foreign banks are willing to lend. We assume the government guarantee does not extend to cover the equity investment of the owners of financial intermediaries, which remains at risk.[8] The guarantee therefore only affects financial intermediaries indirectly through the interest rate at which foreign banks are willing to lend to them.

In the following sub-section we consider the behaviour of the government, and in particular its incentive to honour the guarantee. We then consider the behaviour of foreign banks and their decision to set the interest rate. In each case we consider the short run and long run separately. In the short run we take k as given, but in the long run k is driven by r according to (10) above.

3.1. Government Incentives

If the government honours the guarantee it must raise sufficient funds through taxation to pay for this. Each period, after the productivity shock is realised, the bail-out cost per head, t, is given by the debt repayment to banks, less output and capital after the wage has been paid:

[8] We could model the outcome with more or less generous guarantees. For example, we could consider the case where the guarantee is extended to cover some (or all) of the equity invested by the owners of financial intermediaries. The economy is more likely to become vulnerable to a financial crisis if guarantees are more generous as the over-investment problem is exacerbated.

$$t = z(1+r)k - (\alpha + u)k + 2\beta k^2 - k = (m-u)k \qquad \text{when} \quad u < m$$
$$= 0 \qquad \text{otherwise} \tag{16}$$

This commitment might turn out to be extremely costly, in particular if *r* is high and/or *u* is low (a bad productivity shock). Alternatively, we assume the government can choose to renege on the guarantee, but if it does so it must pay a one-off fixed cost. As this is a one-off cost, reneging by the government absolves it of all future commitments to foreign banks. Furthermore, we assume the government cannot choose to enter into similar commitments in subsequent periods – once the government reneges on its guarantee it is unable to (credibly) offer similar guarantees in the future.

The cost of reneging on the guarantee can be regarded as political. Such an action is likely to be costly as it will reduce the credibility of the government, not just in the eyes of foreign banks, but in all policy areas. Alternatively, this cost can be regarded as resulting from the government falling out with its 'cronies' in the financial sector, who benefit from lower interest rates which result from the bail-out promise.

The government effectively faces an optimal stopping problem. Each period it can either renege and pay the one-off political cost per head, *f*, or alternatively it can honour the guarantee and pay the taxation cost *t*. If it takes this second course of action the government incurs an additional liability equal to the expected present-value cost of the guarantee in the subsequent period. To keep the analysis simple we assume the government does not care about the future and so the problem reduces to a simple comparison between *t* and *f* in any one period.[9] The government will renege on its guarantee if $t > f$, and so substituting for *t* the government will only fulfil the guarantee when the productivity shock is above a trigger level, $\tilde{u}$, where,

$$\tilde{u} = \begin{cases} 0 & \text{when} \quad f \geq mk \\ -\alpha + 2\beta k - 1 + z(1+r) - f/k & \text{when} \quad mk - k < f < mk \\ 1 & \text{when} \quad f \leq mk - k \end{cases} \tag{17}$$

[9] Relaxing this assumption does not alter the qualitative features of the model. See footnotes 14 and 15 below.

where *m* is defined by (3).[10] In the short run, when the capital stock is fixed, $\tilde{u}$ is increasing in the interest rate: when the interest rate rises, the losses of financial intermediaries increase, the cost of honouring the guarantees rises, and it becomes more likely that the government will renege on the guarantee. More precisely, the rate at which $\tilde{u}$ increases with *r* is equal to *z*: this is because as the interest rate increases the cost to the government of honouring the guarantee increases at the rate zk – which is the amount of capital financed by borrowing – and this must be offset by a better productivity shock, which increases output at a rate equal to *k*.

However, in the long run, when the capital stock varies, this relationship between $\tilde{u}$ and *r* changes and will be reversed if *k* is sufficiently sensitive to changes in *r*. This is because a higher interest rate means that the amount of capital invested is so much smaller that the cost of honouring the guarantees falls, causing $\tilde{u}$ to decrease. In the long run *k* is given by (10). By substitution into (17) the trigger value, $\tilde{u}$, becomes:

$$\tilde{u} = \begin{cases} 0 & \text{when} \quad f \geq (1-q)(2+\alpha - z(1+r) - q)/2\beta \\ 1 - q - \dfrac{2\beta f}{2+\alpha - z(1+r) - q} & \text{otherwise} \end{cases} \tag{18}$$

From (18) we can infer that in the long run $\tilde{u}$ is decreasing in the interest rate.[11] Also, since *k* must be non-negative, the parameter restriction implied by (10) means that $\tilde{u}$ is strictly less than one. The reason for this is that, as already noted, the level of capital chosen by financial intermediaries will be such that they make profits in the best state of the world (in order that they achieve an expected return on equity equal to the world interest rate). Thus, because they must make profits when $u = 1$, and for some levels of *u* below unity, the government must be willing to honour the guarantee for these levels of *u*, however low is *f*, because honouring the guarantee would be cost free.

3.2. Foreign Banks and the Equilibrium Interest Rate

In this sub-section we consider how foreign banks set the market interest rate, *r*, given that the government guarantees lending to financial intermediaries. The interest rate functions that we

[10] From (17) we can determine that $\tilde{u} < m$ given $f > 0$. This is because financial intermediaries do not default, and so a bail out is not required, when $u \geq m$. This means $\tilde{u} = 1$ requires $m > 1$, and so the government will only ever renege for sure in a situation where financial intermediaries default for sure.

[11] The present paper shows that this is the case with a quadratic production function. In Irwin and Vines (1999) we show this is also true for a Cobb-Douglas production function in the case where $z = 1$.

derive in this sub-section are central to the model, but the interpretation of these functions is difficult and complicated. For this reason we go through both the derivation of the functions and the explanation of the results in some detail.

The Short-Run Interest Rate Function

In the short run the capital stock is fixed. There are three cases to consider. First assume $k < \bar{k}$ given by (8) (this must be true at the pre-guarantee long-run equilibrium). We already know that without a guarantee foreign banks will set the equilibrium interest rate at $r = r^{SR}$ and the probability of default will be $m = m^{SR} < 1$ (defined by 6 and 7 respectively). Now consider the impact of a guarantee.

Suppose that foreign banks believe the government will honour the guarantee when $u > \hat{u}$, where $\hat{u}$ is some arbitrary conjecture within the relevant range $0 \le \hat{u} \le 1$. If $\hat{u} \ge m^{SR}$, then the guarantee has no effect on the interest rate set by foreign banks, and so $r = r^{SR}$. (This because, if $u \ge m^{SR}$, financial intermediaries do not default, and so foreign banks do not need a bail out). If, on the other hand, $\hat{u} < m^{SR}$, the effect of the guarantee will be to increase the range of shocks over which foreign banks expect full repayment, and as a result $r < r^{SR}$. Assuming $\hat{u} < m^{SR}$, the expected repayment to foreign banks (per unit of labour employed) is:

$$Ev^B = (1-\hat{u})(1+r)zk + \int_0^{\hat{u}} ((\alpha + u)k - 2\beta k^2 + k)du \tag{19}$$

By solving this integral and equating this to the return from investing at the risk free world interest rate, $(1+r^*)zk$, we get the following condition for the equilibrium interest rate:

$$(1-\hat{u})(r-r^*)zk = \hat{u}\left[(1-\hat{u})/2 + 2\beta(k-\bar{k})\right]k \tag{20}$$

The left hand side of this equation shows debt, *zk*, times the excess return on debt, $r - r^*$, that the foreign banks earn when the government honours its guarantee, times the probability, $1-\hat{u}$, that the government does honour the guarantee. The right hand side can be shown to be the probability that the government reneges, $\hat{u}$, times the shortfall in repayment, relative to r^*, that foreign banks expect to receive conditional on the government reneging. Consider this second term:

$$\text{E (Shortfall} \mid \text{Renege)} = \left[(1-\hat{u})/2 + 2\beta(k-\bar{k})\right]k \tag{21}$$

Notice that this expected shortfall is zero if $\hat{u} = 1$ (in which case there is no effective guarantee) precisely when $k = \bar{k}$ (simply because $\bar{k}$ is defined as the maximum level of *k* at which foreign investors are prepared to lend). The expected shortfall relative to r^* increases when *k* increases above $\bar{k}$, because the profitability of investment is decreasing in *k*. Also note that the expected shortfall, given that the government actually reneges, increases as $\hat{u}$ goes below 1. In fact, since the expected value of *u*, conditional on $u < \hat{u}$, decreases half as fast as $\hat{u}$ (because *u* is uniformly distributed), it follows from the production function that the expected shortfall will increase at the rate $k/2$ times any decrease in $\hat{u}$. This fact will be of importance in the next section.

We can solve for *r* to determine the equilibrium interest rate under the government guarantee when $\hat{u} < m^{SR}$:

$$r = r^* + \frac{\hat{u}}{2z} + \frac{2\hat{u}\beta(k - \bar{k})}{(1-\hat{u})z} \tag{22}$$

Note that when $k < \bar{k}$, providing $\hat{u} < m^{SR}$, then $\partial r / \partial \hat{u} > 0$ and $\partial^2 r / \partial \hat{u}^2 < 0$. When $\hat{u} = m^{SR}$ equation (22) reduces to (6), and as $\hat{u} \to m^{SR}$, $\partial r / \partial \hat{u} \to 0$, so the value for *r* shown in (22) is 'smooth pasted' onto r^{SR} at $\hat{u} = m^{SR}$. The relationship between the interest rate and $\hat{u}$ is thus as summarised in figure 2 below. The actual interest rate function is shown in bold, being a composite of functions (6) and (22).

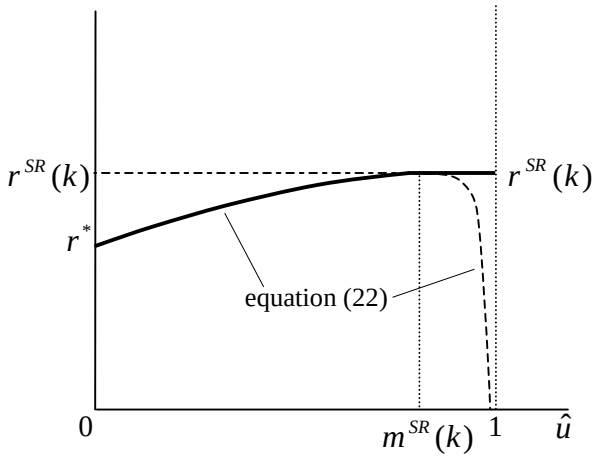

Figure 2: $k < \bar{k}$

Second, consider the case where, under the influence of government guarantees, capital has accumulated beyond $\bar{k}$. At this level of capital the probability of default without a guarantee would be unity and there would be no interest rate at which foreign banks would lend to financial intermediaries. When $k > \bar{k}$, the productivity of capital has fallen to such an extent that, given the distribution of shocks and the corresponding probability of repayment, there is no market interest rate at which foreign banks are willing to roll-over the debt of financial intermediaries without the government bail-out guarantee. Indeed, this is how $\bar{k}$ is defined. Because in this case the guarantee is effective for all values $\hat{u}$ could take, the interest rate function is given by (22) over the entire range, $0 \le \hat{u} \le 1$. This is shown in figure 3 below.

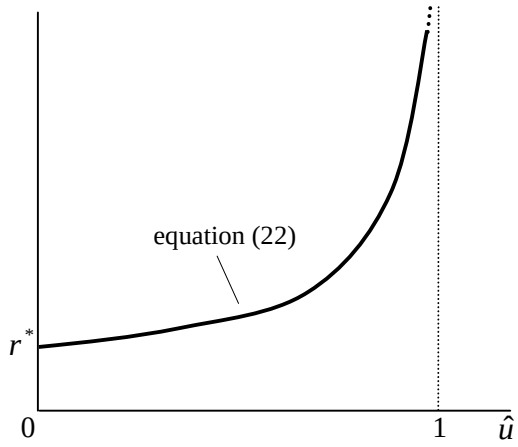

Figure 3: $k > \bar{k}$

Note that when $k > \bar{k}$ the second derivative of *r* with respect to $\hat{u}$ is now greater than zero, in contrast to the case when $k < \bar{k}$. Note also that, not only does the interest rate increase over the entire range, $0 \le \hat{u} \le 1$, but it tends to infinity in the limit as $\hat{u}$ goes to one. The interest rate increases with $\hat{u}$ because the expected shortfall in the repayment when the government reneges must be balanced by an expectation of excess payment when the government honours the guarantee. As $\hat{u}$ increases, the probability of the government reneging increases, and so the payment when the government does not renege must also increase (higher *r*). It follows that in the limit as the probability of default approaches one, the payment in the unlikely event that the government does not renege must tend to infinity. When $k < \bar{k}$, the interest rate given by equation (6) acts as a ceiling on the interest rate function, because there is a range of shocks good enough to prevent financial intermediaries defaulting at a market interest rate, even without government support. With $k > \bar{k}$ no such ceiling exists.

Finally, consider the intermediate case where $k = \bar{k}$. This is the highest level of the capital stock at which foreign banks will lend to financial intermediaries in the absence of a government guarantee. Once again, the interest rate is given by (22) over the entire range, $0 \le \hat{u} \le 1$. But from (22) we can see that in this case the interest rate is a linear function of $\hat{u}$. The intuition for this result, and its generality, can be explained as follows. We can see from (21) that $\mathrm{E}(\text{Shortfall} \mid \text{Renege}) = 0$ when $k = \bar{k}$ and $\hat{u} = 1$. This follows from the definition of $\bar{k}$; when $\hat{u} = 1$, there is effectively no government guarantee, and so it is precisely when $\mathrm{E}(\text{Shortfall} \mid \text{Renege}) = 0$ that foreign banks are *just* willing to lend to financial intermediaries. Furthermore, because $\mathrm{E}(\text{Shortfall} \mid \text{Renege})$, given by (21), is linear in $\hat{u}$, it then follows that it must be proportionate to $1 - \hat{u}$ when $k = \bar{k}$. As this term will cancel out the term for the probability the government honours the guarantee on the left side of (20) above, the interest rate is a linear function of $\hat{u}$ in this intermediate case. Given the distribution for *u*, this result will generalise to any production function for which $\mathrm{E}(\text{Shortfall} \mid \text{Renege})$ is linear in $\hat{u}$.[12]

The Long-Run Interest Rate Function

In the long-run the capital-to-labour ratio is optimally adjusted by financial intermediaries according to (10). The probability of default in the absence of a guarantee, m^{LR}, is given by (13). This is less than one for $z < 1$, and equal to one when $z = 1$.[13] In the long-run, therefore, there is always a productivity shock good enough to prevent financial intermediaries defaulting, with or without a government guarantee. The reason for this is that financial intermediaries optimally adjust *k* in the long run, and in order to make an expected return which is adequate to cover the opportunity cost of equity investment, they must make profits (and therefore do not default) in the best state of the world, and for some range of lower values of *u*.

[12] For example, this is true for a Cobb-Douglas production function.

[13] Note that $q = 0$ when $z = 1$.

In the long-run case the interest rate when $\hat{u} \geq m^{LR}$ is given by (12). Over this range the interest rate is independent of $\hat{u}$, as financial intermediaries do not default, and so the government guarantee does not provide foreign banks with any additional protection. When $\hat{u} < m^{LR}$ we can determine the long-run interest rate by substitution of (10) into (22):

$$r = r^* + (\hat{u}/z)(1 - q - \hat{u}/2) \tag{23}$$

In the long-run, similar to the short-run case where $k \leq \bar{k}$, the interest rate function is a composite of (12) and (23). This function has similar properties to those shown in figure 2 above. The interest rate equals r^* when $\hat{u} = 0$ and is increasing in the range $0 \leq \hat{u} < m^{LR}$. For higher values of $\hat{u}$ the interest rate is finite.

4. Equilibria of the Model

In equilibrium we must have $\hat{u} = \tilde{u}$. In this section we characterise the long-run and short-run equilibria of the model in turn.

4.1. Long-Run Equilibrium

We know from sub-section 3.1 that in the long run $\tilde{u}$ decreases with *r*. From section 3.2 we also know that *r* is increasing (strictly, non-decreasing) in $\hat{u}$, which in equilibrium equals $\tilde{u}$. Taken together these properties mean the long-run equilibrium will be unique. In figure 4 below we plot both functions on the same diagram and show the unique equilibrium point of intersection.

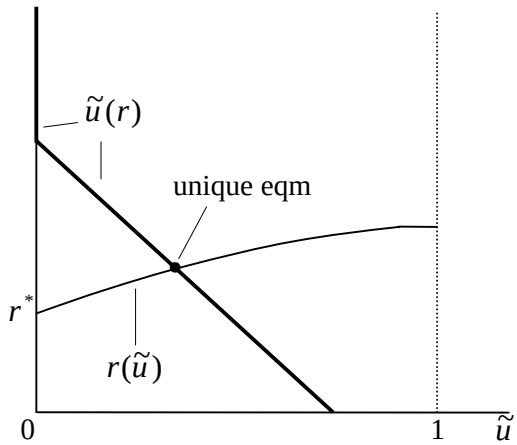

Figure 4

In figure 4 we show an interior solution. From (18) we can deduce that if *f* is large enough the long-run equilibrium will be a boundary solution with $\hat{u} = \tilde{u} = 0$ and $r^{LR} = r^*$. The condition for this is that:

$$f \geq (1-q)\left(2 + \alpha - z(1+r^*) - q\right)/2\beta \tag{24}$$

For expositional purposes and to sharpen our point we assume this condition holds in the rest of this paper.[14]

From (10) we can determine the capital-to-labour ratio at the long-run equilibrium. Setting $r = r^*$:

$$k^{LR} = \left(2 + \alpha - z(1+r^*) - \sqrt{2(1-z)(1+r^*)}\right)/2\beta \tag{25}$$

Once the guarantee is introduced, assuming *f* is sufficiently large so that the unique long-run equilibrium is a boundary solution, *k* will gradually rise towards this level, which is necessarily above the pre-guarantee level given by (14). By differentiation of (25) with respect to *z*, given (15), we can see that k^{LR} is increasing in *z*. This means that, as the debt-to-equity ratio increases (implying higher *z*), the over-investment problem at the long-run equilibrium is exacerbated. As a result, as we see below, it is more likely that the economy will become vulnerable to financial crisis.

4.2. Short-Run Equilibria

In the short run, with the capital stock held fixed, $\tilde{u}$ is (linearly) increasing in *r* (equation 17).

Once again, if *f* is sufficiently large, a boundary solution with $\hat{u} = \tilde{u} = 0$ and $r = r^*$ will exist. In this case, the government will honour its guarantee, however bad the shock, if the interest rate is r^*, and because it will do so, the interest rate can take the (low) value of r^*. In both parts of figure 5 a boundary solution equilibrium is depicted as the $r(\tilde{u})$ line is below the $\tilde{u}(r)$ line at $\tilde{u} = 0$. The condition on f necessary for this equilibrium to exist is weaker than condition (24). We therefore assume that this equilibrium does exist.

[14] In deriving this condition we simplified the optimal stopping problem by assuming the government does not care about the future. However, intuitively it makes sense that even if we relax this assumption there will

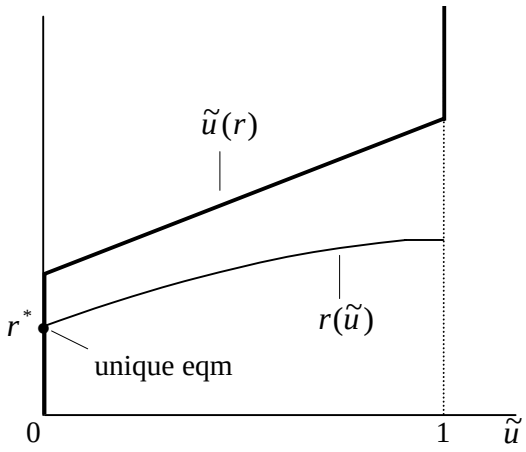

Figure 5a: $k < \bar{k}$

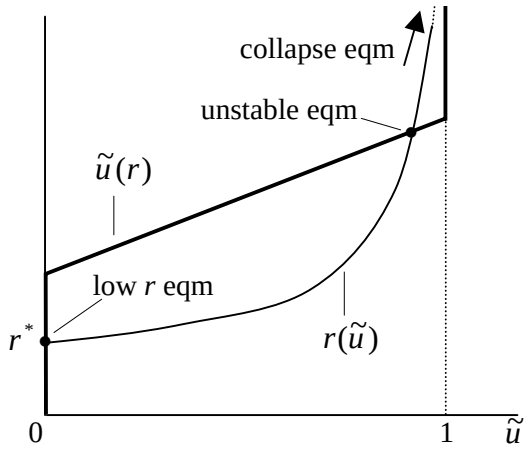

Figure 5b: $k > \bar{k}$

For values of k at or below $\bar{k}$ the situation is as depicted in Figure 5a and we can rule out multiple equilibria. The reason for this can be seen by considering how $r(\tilde{u})$ behaves as $\tilde{u}$ increases above the value of $\tilde{u} = 0$ which it takes at the boundary solution described above. From (22) above we can see that when $k = \bar{k}$ the $r(\tilde{u})$ line is a straight line which is only half as steep as the $\tilde{u}(r)$ line. This is sufficient to rule out multiple equilibria. Similarly, when $k < \bar{k}$ the $r(\tilde{u})$ line has a slope which is half that of the $\tilde{u}(r)$ line when $\tilde{u} = 0$, and which decreases as $\tilde{u}$ increases. Inspection of Figure 5a then shows that multiple equilibria certainly cannot happen in this case. When $k > \bar{k}$, however, the $r(\tilde{u})$ line has a slope which begins to rise as soon as $\tilde{u} > 0$, and tends to infinity as $\tilde{u}$ tends to one. Inspection of Figure 5b then shows that multiple equilibria exist.[15] In this case there are necessarily three equilibrium points of intersection between the two functions. Importantly, there is a 'collapse' equilibrium for which the expectation of the government reneging is self-fulfilling: if foreign banks believe there is no prospect of the government honouring its guarantees ($\hat{u}$ tends to one) interest rates are raised to infinity, and so there is indeed no way the government can afford to honour the guarantee ($\tilde{u} = 1$). If the economy flips to this collapse equilibrium the government is *forced* to renege.

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always be a cost of reneging, *f*, that is sufficiently large to ensure the government never reneges. Accordingly, the long-run equilibrium will be a boundary solution, with *k* given by equation (25).

[15] Note that this condition for the existence of multiple equilibrium is not dependent on the simplifying assumption, used to derive (17), that the government does not care about the future. Together with the comment in footnote 14, this is the basis for our claim in footnote 9 that relaxing this assumption does not change the qualitative features of the model.

A boundary solution and a collapse equilibrium are indicated in figure 5b. Both of these equilibria are stable. In addition, there will also exist an unstable interior solution equilibrium with $0 < \tilde{u} < 1$. Because this equilibrium is unstable we do not consider it further.

5. Vulnerability to Financial Crises

We assume that, if the government ever reneges, it cannot credibly offer similar guarantees in the future, and so the long-run equilibrium changes. Prior to reneging the guarantee raises the long-run equilibrium capital-to-labour ratio (from 14 to 25). But after reneging the capital-to-labour ratio must revert to the pre-guarantee level, with a withdrawal of foreign investment. This has implications for output and is what we call a financial crisis.[16]

Multiple short-run equilibria exist if $k > \bar{k}$. Given condition (24), a low-interest-rate equilibrium, in which the government honours the guarantee for sure, exists for all values of *k*. But for $k > \bar{k}$ a 'collapse' equilibrium also exists because in the limit as the conjecture $\hat{u} \to 1$ the interest rate charged by foreign banks tends towards infinity, thus validating the conjecture as the government cannot bail-out the losses incurred at infinite interest rates. When $k < \bar{k}$ no collapse equilibrium exists, because in the limit as $\hat{u} \to 1$ the interest rate rises to a finite value at which the government *can* afford to bail out financial intermediaries. This finite interest rate is the rate foreign banks would demand in the absence of any government guarantee – and so this rate places a cap on the interest rate when there is a guarantee. If *k* is too high, however, there is no interest rate at which foreign banks would be willing to roll over the debt of financial intermediaries in the absence of a guarantee, and so there is no interest rate cap.

For $z = 1$, the pre-guarantee equilibrium capital stock (equation 14) equals $\bar{k}$, and so multiple equilibria exist for *all* capital-to-labour ratios *above* the pre-guarantee ratio. The economy is therefore vulnerable immediately following the introduction of the guarantee. More generally,

[16] In two related papers, one of us has presented an extensive informal account of the East Asian crisis which focuses on the interconnections between financial and currency crisis, and argues that crisis became so severe *because* of these interconnections. (Corbett and Vines, 1999a,b) The critical extra feature resulting from this interconnection was – we argue – that the fixed exchange rate regimes pursued in East Asia before the crisis induced massive unhedged borrowing in foreign currency. When the currency depreciated this raised the burden of that borrowing and led to a worsening of the financial crisis.

for $z<1$, the economy may never become vulnerable, or may only become so as sufficient capital is accumulated during the transition to the new long-run equilibrium. The condition for the economy to be vulnerable at the new long-run equilibrium is $\bar{k} < k^{LR}$. After substitution of (8) and (25) this condition becomes:

$$z > 1 - 1/(8(1+r^*)) \tag{26}$$

The key variable which determines whether the economy will ever become vulnerable to a financial crisis is *z*, the proportion of the capital stock financed by borrowing from foreign banks. There are two reasons why this variable is critical. First, as *z* increases, there is a greater incentive to over-invest (k^{LR} rises with *z*), and so at the long-run equilibrium profitability falls. Second, as *z* increases, the equity cushion against default is reduced, and so lending by foreign banks is riskier, other things being equal (*e.g.* the credibility of the government guarantee). For these reasons it is less likely that foreign banks would be willing to roll over debt at the long-run equilibrium capital-to-labour ratio, in the absence of a government guarantee. If this is the case, then multiple short-run equilibria exist, with the possibility of a switch to the collapse equilibrium and, as a result, a financial crisis.[17]

6. Conclusion

In this paper we have shown how an 'East-Asian-style' financial crises can occur with a collapse in investment and output. The multiple-equilibrium feature of the model means that any collapse will be sudden and unpredictable. But in this paper we have identified the critical factors which create a *vulnerability* to this form of crisis. There are two essential ingredients. First, government guarantees fuel moral-hazard driven over-investment, along the lines outlined by Krugman. Second, high debt-to-equity ratios exacerbate this over-investment problem and increase the riskiness of a given level of lending by foreign banks. This second contributing factor suggests there is a clear role for regulation of the financial sector to control debt-to-equity ratios and thus to prevent vulnerability from arising.

[17] Condition (26) is strong, implying that high capital and debt levels are required before the economy can potentially become vulnerable to a financial crisis of this sort. However, more generous guarantees, for example which bail-out a proportion of losses incurred by equity investors, will remove more of the downside risk from investment, thus creating an incentive for further over-investment. As a result the long-run capital-to-labour ratio will rise and so the condition on *z* for vulnerability at the long-run equilibrium will be weaker.

The analysis also demonstrates that the profitability of financial intermediaries is the key indicator of the potential for this type of crisis. Multiple short-run equilibria only exist when the profitability of investment undertaken by financial intermediaries has fallen to such an extent that there is no market interest rate at which foreign banks would roll over the debt without a government guarantee. It is in this situation that vulnerability to financial crisis arises.

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