Project Contingent Repudiation Risk

in the Model of North-South Lending.

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Abstract.
The present model proposes an extension of the Gertler and Rogoff (1990) model of international lending in the presence of moral hazard and the possibility of state-contingent and project-dependent repudiation risk along the lines of Lane (1999). By linking the level of repudiation risk to the size of the project, we show that investment projects arising in the marketplace will be constrained in the size of capital by the repudiation risk, even in case of the repudiation risk applying to the bad state of nature alone. This amplifies the results shown in Lane (1999) and can be interpreted as a debt ceiling within the context of international lending. The model provides a natural connection between the exogenous monitoring institutions development, the degree of corruption and bankruptcy/limited liability laws to the ability of entrepreneurs to raise investment funding.

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Introduction.

In recent years, the role of risk and, in particular, repudiation risk as a determinant of investment decisions and capital flows has been highlighted by a plethora of models. At the same time, traditional models of repudiation risk have invariably avoided endogenising the potential relation between risk and the investment project environment within the framework of moral hazard and agency problems. Yet, as both anecdotal and empirical evidence suggest, variations in the degree of limited liability and repudiation risk may be related to the projects' attributes such as the size of the investment outlay or the volume of debt relative to the collateral held by the entrepreneur.

While moral hazard and agency problems have been subject to extensive theoretical research, the latter aspect of repudiation risk remains largely unexplored today. At the same time, the project contingency of repudiation risk offers several potential avenues for developing insights into the lending markets operations. Specifically, linking repudiation risk directly to the size of the investment allows for both the endogenising of risk into the decision making of an entrepreneur and establishing the connection between limited liability and the incentives on behalf of the entrepreneur to pursue return-maximising behaviour.

Another interesting connection can be drawn from the relation between repudiation risk and the project environment. It can be argued that the size of investment or debt relates to the issue of monitoring and enforcement costs, and more broadly to the role that institutions can play in fostering the investment environment. For example, in societies with developed democratic institutions, such as independent judiciary, media, and with greater political accountability of the elected and appointed officials, the size of the project may determine the degree of its exposure to public and political pressures. Thus larger investment projects may enjoy lower monitoring and collection costs faced by the lenders. Naturally, such a case would imply that repudiation risk may be decreasing in the size of the investment.

On the other hand, a popular saying suggests that a default of a small company signifies a costly failure to the entrepreneur, while a default of a larger project is a 'bank's headache'. This implies that repudiation risk may be an increasing function of investment or debt size. The latter relation may be associated with the specific environment of corruption, where large projects may be subject to a restriction on the ability of foreign investors to collect project payoffs in case of default, while the smaller projects may be free from such a restriction. Alternatively, such a case may arise whenever larger debt held by the entrepreneur yields a greater bargaining power for the entrepreneur vis-à-vis her lenders. More intuition in this is given in the paper below.

Additionally, it is worth mentioning that in the model presented below, in analysing the effects of the project size on repudiation risk, we can treat interchangeably either total capital outlay to the project or the level of debt held by the entrepreneur. The reason for this, as will be clear from the following discussion, is that the level of debt is determined by the capital needs in a linear fashion. This implies that holding personal endowment of wealth available to the entrepreneur fixed, a higher level of debt will be required to attain a higher level of capital outlay in the project.

The majority of repudiation risk literature focuses on the open economy side of the macroeconomic models, while the larger share of moral hazard models is concerned with closed economies. For example, a seminal paper by Gertler and Rogoff (1990) develops a model of investment under uncertainty in the presence of moral hazard that ignores the possibility of repudiation risk. As highlighted in Lane (1998), this model, according to the authors' admission, cannot be used to distinguish investment flows between two states within the US and the two sovereign countries. Similarly, Holmstrom and Tirole (1998) focus on the closed-economy aspect of agency risk without providing an analysis of the repudiation risk, or the link between the nature of the project and the level of repudiation risk. Lane (1998 and 1999) extension of the former model to include repudiation risk moves it into open economy macroeconomics.

Yet, repudiation risk, specifically state-contingent repudiation risk accruing to the 'bad' state of nature alone can also be interpreted as a limited liability clause under bankruptcy laws. If this is the case, it is hard to assign such risk exclusively to the external capital flows: limited liability clauses apply to both the projects located in the home country financed from abroad, and to those financed with domestic lenders. One way of distinguishing between the two sources of financing in case of state-contingent asymmetric repudiation risk is to suggest that domestic lenders may have an advantage relative to foreign lenders with respect to their ability to collect on the defaulted project.

Finally, the distinction between the state-contingent asymmetric repudiation risk (interchangeably: the limited liability clause) and the symmetric risk that applies to both states of nature can serve as a separation point for contrasting the internal lending markets conditions against the external lending. Clearly, in the presence of political corruption, paternalistic or nationalistic pressures on lenders, both international and domestic lenders may face the same constraints. Furthermore, as argued earlier, limited liability usually applies to both types of lending as well. However, it is plausible that external lenders may be subject to a broader constraint of the repudiation risk on their ability to collect the repayment on both successful and failed projects. At the same time, domestic lenders may enjoy a greater power over the entrepreneurs, at least in the case of a successfully completed investment project. Our model allows for such a distinction and for an intuitive interpretation of its implications for the lending markets. As shown below, if external lenders face symmetric repudiation risk, while domestic lenders only face limited liability clause, our model predicts that the economy may have both functioning domestic lending markets and completely shut foreign capital inflows. This is the result that does not arise in the benchmark models developed by Gertler and Rogoff (1990) and Lane (1999).

To summarise, the current study is designed to fill these gaps by extending Gertler-Rogoff-Lane framework to include consideration of the project contingent repudiation risk. In the following, we assume that the importance of repudiation risk in investment decisions rests, in part, on the differences amongst various projects. For simplicity we assume that this endogeneity of repudiation risk is linked to a specific characteristic of the project, namely its size. However, the model presented below can be easily extended to cover many other contingencies within the realm of the project environment.

With this goal in mind, the paper is organised as follows. Part 1 below introduces and discusses the general model of investment under uncertainty, moral hazard and repudiation risk. Part 2 provides analysis of the case-specific solutions of the model in case where the repudiation risk in increasing in the total capital outlay for the project. Appendix 1 supplies the mathematical details of the model.

Part 1. The Model of the Project-Contingent Repudiation Risk.

In the model presented below we closely follow the structure and methodology developed by Gertler and Rogoff (1990) and extended by Lane (1999).

There are two types of risk-neutral agents, each living two periods t and $t+1$: entrepreneurs and lenders. There is one risky investment project that involves investment at date t with payoffs realised in period $t+1$. Hence, lenders are interested in maximising the expected rate of repayment on the project, while entrepreneurs maximise their expected utility over a choice of the second period consumption. This assumption that only period $t+1$ consumption matters to the entrepreneur is a simplification that does not alter the results. In fact, the model can be solved for the case of intertemporal optimisation over two periods while retaining all qualitative results presented below. Thus entrepreneurs maximise:

$$E_t U(C_{t+1}) = E_t C_{t+1} \tag{1}$$

Income available to entrepreneurs arises from two sources. Original, period t endowment of wealth, W, can be invested in a risky project with the state contingent payoffs described below, and the risk-free asset yielding the certain gross rate of return, R. The risky investment technology is given as follows. At date t the entrepreneur uses her own funds, W, together with the borrowed amount of b to finance capital formation in the amount of k. This capital is then applied to the risky investment project, following which the entrepreneur chooses the level of effort to be applied to the project.

The project yields at date *t+1* a return θ_G with probability $\pi(k)$ corresponding to the 'good' state of nature, or a return θ_B with probability $1-\pi(k)$ corresponding to the 'bad' state of nature. We assume that $0 \leq \theta_B < \theta_G$. The level of effort (capital outlay to the project) under the possibility of investing the borrowed funds in the risk-free asset is private information available to the entrepreneur. At date *t,* upon borrowing funds for investment, the entrepreneur commits to repay state-contingent rate of return $Z_G \geq Z_B$. However, the lender faces an additional risk of default due to the limited liability or repudiation risk. We distinguish here between the two risks only in the context of state-contingency. Roughly, in our model, limited liability is synonymous to the repudiation risk applying in the 'bad' state of nature alone. Whenever the lenders ability to collect on the completed project is restricted in both states of nature, we refer to this situation as pure repudiation risk. Thus after the realisation of the project, lenders may collect only a share of final output. This share is project-size-contingent, so that

$$\alpha(k)\theta_i \geq Z_i \quad i = G,B \tag{2}$$

In equation (2), $\alpha'(k) > 0$, corresponds to the situation in which repudiation risk is decreasing in the size of capital outlay. Alternatively, $\alpha'(k) < 0$ will be associated with the case of repudiation risk increasing in the size of investment project. Note that, since the investment size is linearly related via budget constraint to the entrepreneur's debt liability, equation (2) can be interpreted as either a repudiation risk linkage to capital outlay or to a debt liability of the entrepreneur, or both, as described below. In addition, in equation (2) above, if $\alpha(k)$ is independent of the state of nature, the model corresponds to the case of repudiation risk analysis presented in Lane (1998). On the other hand, whenever $\alpha_i(k)$ varies with the state of nature, our model captures the case of limited liability as presented in Gertler and Rogoff (1990).

In the present paper, *k* may alternatively refer to either the macroeconomic aggregate level of capital flows or to a firm level investment. In the first case, the model can be used to describe the nature of capital investment projects financed by the sovereign debt markets. Here, repudiation risk and/or limited liability may be related to the issues of corruption, as well as to the issue of pure sovereign risk. Under the second assumption, firm investment projects may be subject to corrupt protection that restricts foreign lenders ability to capture project proceeds or firm assets.

For reasons of brevity, we shall focus hereinafter only on the case where repudiation risk is increasing in the size of the investment project, so that $\alpha'(k) < 0$. The intuition behind this assumption is as follows.

In a democratic society with developed media and socio-political checks and balances on bureaucracy, high profile (large *k*) investment projects are associated with higher degree of visibility and thus public scrutiny. The resulting reduction of information costs makes larger projects easier to monitor than smaller ones. In addition, with a high degree of public exposure, such projects are less subject to corruption (for example, media exposure in democratic setting increases the cost of corruption) and therefore are associated with lower repudiation risk than smaller, less visible, ones. In terms of our parameter values, this relationship implies that $\alpha'(k) > 0$. This is the idea that would be applicable in discussing capital flows within the OECD countries, or in parlance of this paper, the North-North capital flows.

However, as evidence suggests, in the developing world with nascent public participation institutions, large-scale investment projects may be subject to higher political, nationalistic, paternalistic, and other pressures. This situation can warrant the direction of the link between the size of the project and the repudiation risk involved that we are considering below. Larger debt, or investment level overall, implies greater power on behalf of the domestic entrepreneur to bargain with foreign lenders, or in terms of our parameters, $\alpha'(k) < 0$. As such, a negative relationship between the size of capital outlay required for the project and the ability of the lenders to collect on the project (whether failed or not) is more salient in the case of North-South capital flows that we are discussing in this model.

Similarly, at the aggregate level, if *k* denotes the ability of economy to raise external capital, higher exposure to foreign capital, as consistent with higher *k*, may be associated with a greater popular resentment toward foreign investment. This would imply higher ability of corrupt leadership to protect domestic investment projects vis-à-vis foreign investors. As political costs of limited repudiation practices to the state fall, $\alpha'(k) < 0$ is a reasonable assumption capturing such possibility.

Denote by subscripts *G* and *B* the realisations of *Good* and *Bad* states of nature respectively. Then, let

$$Z = Z_G - Z_B$$

$$\theta = \theta_G - \theta_B. \tag{3}$$

be the differences in the project's net repayments and returns across the levels of effort (i.e. across the possible states of nature).

To control for the presence of moral hazard problem in terms of the investment project choice, we impose the standard incentives compatibility constraint according to which the risky projects must yield at least the same rate of return as a risk-free bond:

$$\pi'(k)(\theta - Z) \geq R \tag{4}$$

We further assume that neither future income nor the expected repudiation funds can be leveraged in the debt markets, so that

$$W + b - k \geq 0 \tag{5}$$

Finally, investors must be guaranteed an expected repayment level of at least the amount of the opportunity cost of the risky investment, i.e. *R*:

$$\pi(k)Z + Z_B \geq Rb \tag{6}$$

We are now ready to postulate the optimisation problem faced by an entrepreneur. Without loss of generality, assume that the entrepreneurs are interested in maximising the expected utility in period *t+1*, given by:

$$\max_{\{k,b,Z_G,Z_B\}} E_t C_{t+1} = \pi(k)\left[\theta_G - Z_G\right] + \left(1-\pi(k)\right)\left[\theta_B - Z_B\right] + R\left[W + b - k\right] \tag{7a}$$

subject to constraints (2), (4)-(6).

Denote by $\phi_i, \mu, \gamma, \psi$ the multipliers on constraints (2), (4)-(6) respectively. Then the first order conditions for the general problem are given by:

$$\pi'(\theta - Z) - R + \mu\pi''(\theta - Z) + \pi' Z\psi + \alpha'\left(\phi_G\theta_{G+} + \phi_B\theta_B\right) = \gamma \tag{7b}$$

$$\gamma = (\psi - 1)R \tag{7c}$$

$$\pi[\psi - 1] = \pi'\mu + \phi_G \tag{7d}$$

$$(1-\pi)[\psi - 1] + \pi'\mu = \phi_B \tag{7e}$$

As in Lane (1999) there are two main cases to consider:

Cases 1-3: Repayment constraint (2) does not bind in the good state, while Incentive constraint (4) binds. As shown below this case implies two possibilities for the solution. Under the assumption of a strong or medium repudiation risk (cases 1 and 2) the Gertler-Rogoff solution fails. Under the assumption of a weak repudiation risk (case 3) the Gertler-Rogoff solution applies. All three sub-cases correspond to the situation where repudiation risk applies to the ‘bad’ state of nature alone which we call asymmetric.

Cases 4-5: Repayment constraint binds in both states. In this case the Gertler-Rogoff solution fails. This is the case of repudiation risk being symmetric across the two states of nature. Here we will again distinguish the two possibilities. Independently of whether the repudiation risk is strong or medium relative to the marginal cost of capital, as in case 4, or the repudiation risk is low, as in case 5, the Gertler-Rogoff-Lane solutions do not hold. Furthermore, in case 4, no interior solution exists.

The details of solutions for all cases are provided in Appendix 1.

Part 2. Case-Specific Solutions.

We now proceed to derive the specific solutions to the model corresponding to cases 1-5 outlined above.

2.1. Cases 1-3: State-Contingent Repudiation Risk.

Consider case 1. Since $\gamma > 0$, as shown in Appendix 1 below, the optimal solution to the problem is given by the following equations:

MR curve $$Z = \frac{R(k - W) - \alpha(k)\theta_B}{\pi(k)} \tag{8a}$$

$$b = k - W$$

IC curve $$Z = \theta - \frac{R}{\pi'(k)} \tag{8b}$$

ZZ curve $$\alpha(k)\theta = \mathrm{Z} \tag{8c}$$

First note that by (8c), the *ZZ* curve vertical intercept coincides with that in Lane (1999): $\mathrm{Z}_0 = \alpha(0)\theta$.

Under the assumption of increasing repudiation risk the slope of the *ZZ* curve is negative.

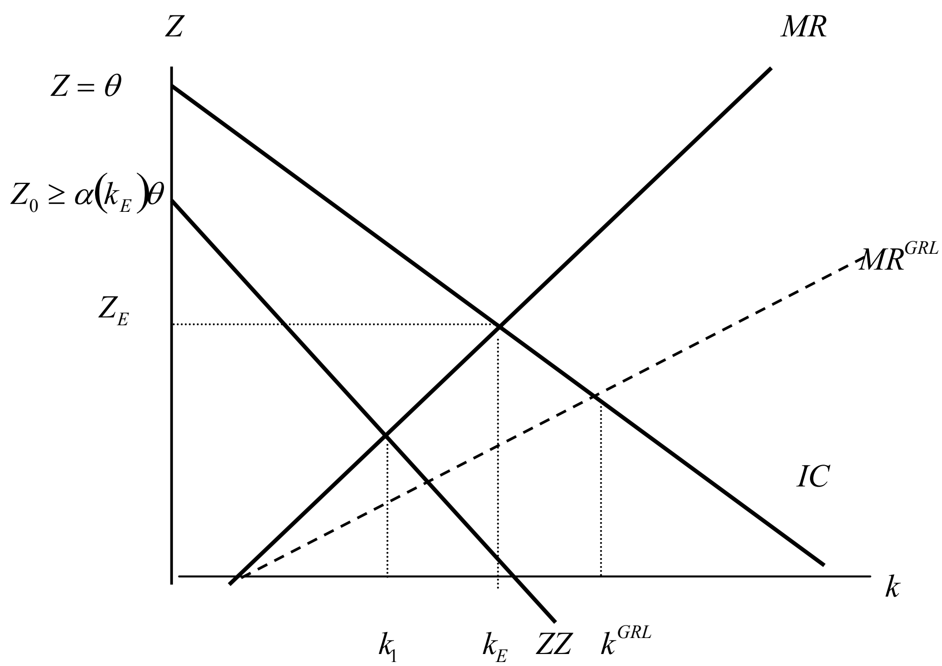
The *IC* curve is fully coincident with the standard *MR* curve in Lane (1999).

The *MR* curve is upward sloping by (7b). However, relative to Lane (1999), the model predicts that the *MR* curve that represents the Return-to-Lenders constraint is steeper in our case than in the benchmark case. This is due to the effect of rising repudiation risk in response to an increase in capital. In Lane (1999), as in the Gertler and Rogoff (1990) paper, the return required by lenders is a rising function of capital however, as the repudiation risk increases with capital allocation, the lenders require higher repayment *Z* at any given level of capital raised, *k*.

Considering the slopes of *ZZ* and *IC* provides a comparison between the marginal costs of the investment level in terms of increase in repudiation risk and the marginal benefits of investment level on probability of success (moral hazard amelioration). This yields two possibilities shown below.

Case 1: $\alpha'(k) < \frac{R}{\theta}\frac{\pi''(k)}{\pi'(k)^2}$ so that the marginal cost of repudiation risk effect due to capital increase exceeds the marginal benefits of lower moral hazard due to capital increase. This is the case of a **strong effect of *k* on repudiation risk**. The slope of *ZZ* curve is steeper than the slope of *IC* curve and the level of capital that can be raised for the project (denoted by k_1) is below that shown qualitatively in Lane (1999) (denoted by k_E). Constraining the repudiation risk to be compatible with non-zero lending, so that $k > W + \frac{\alpha(k)\theta_B}{R}$, Figure 1 below provides a graphical solution. Note that, regardless of the magnitude of the repudiation risk effect, due to the presence of the repudiation risk link with the capital levels, we have in our model an added distortion to capital markets. This distortion, as discussed earlier, increases the rate of return required by lenders for any non-zero level of capital. This, in turn, implies that our *MR* curve is

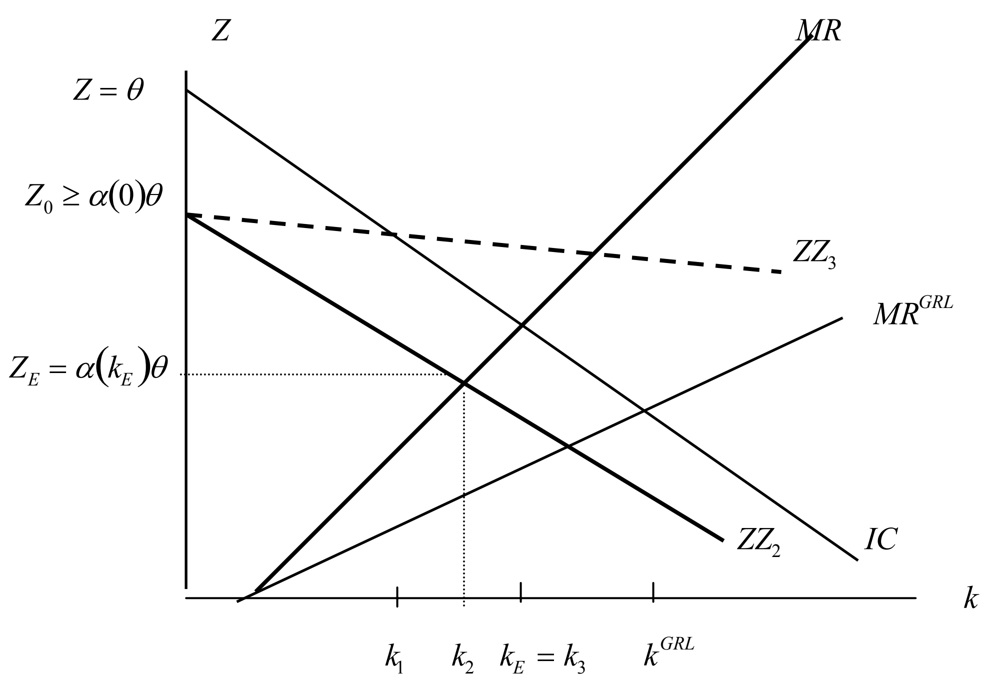
Figure 1. Strong repudiation risk effect.



pivoted upwards relative to the case described in Lane (1999). As the result of this, in the interior solution equilibrium our credit markets can supply only a lower level of capital funds, so that $k_E^{our} < k_E^{GRL}$, where k_E^{our} denotes the interior solution level of investment in our model, while k_E^{GRL} denotes the interior solution in Gertler and Rogoff (1990) and Lane (1999).

Cases 2&3: $\alpha'(k) > \frac{R}{\theta}\frac{\pi''(k)}{\pi'(k)^2}$ corresponds to the cases of **medium (**case 2**) or weak (**case 3**) effect of *k* on repudiation risk**. Slope of *ZZ* is now flatter than slope of *IC* and the position of intersection of *ZZ* and *MR* relative to the intersection of *IC* and *MR* determines the solution. Figure 2 below provides graphical analysis of the solutions.

Figure 2. Medium and weak repudiation risk effects.



In case 1, the repudiation risk increases with capital faster than the associated increase in the probability of the project success, $\pi(k)$. Hence, the marginal benefit of investing in a larger project is completely outweighed by the marginal cost from the higher repudiation risks. The incentive constraint for the entrepreneur to adopt a high level of effort binds, and its shadow value is lower than that of the repayment constraint. The entrepreneur then has an added incentive to default on the project since, in case of default, she will collect the repudiation proceeds. The result is that lenders will require higher collateral and will produce lending caps whereby no lending will occur in excess of k_1. Overall, these results are similar in nature to the labour market results derived by Farmer (1985). Farmer (1985) shows that information asymmetry in presence of repudiation risk (or limited liability) may result in optimal lending contracts becoming partially non-state contingent. Gurdgiev (2004, Chapter 4) provides a more extensive discussion of these effects of the repudiation risk on capital markets in the closed economy setting.

In case 2, the moderate impact of a capital increase on repudiation risk insures that the marginal benefit of a higher probability of success dominates the marginal cost of a rising risk of repudiation. However, the incentive to the entrepreneur to default on the project remains relatively high, while the investors' requirements for guarantees on repayment remain fixed. This implies that a decrease in repayment pledged by the entrepreneur due to a fall in α continues to amplify the investment distortion due to the repudiation risk and thus constrain the capital funding available to k_2 such that $k_1 < k_2 < k_E = k_3$.

Only when the marginal effect of rising repudiation risk is extremely low will the unconstrained interior solution take place. This is described the case 3 above.

Note that an increase in the entrepreneur's collateral results, as in Gertler and Rogoff (1990) and Lane (1999), in an increase in the overall capital funds available to the entrepreneur.

Consider a rise in the initial wealth endowment, *W*. A resulting shift in the *MR* curve rightward implies that in all three sub-cases above, the capital availability increases. However, even in case 3, this increase will not be identical in size to that of Gertler and Rogoff. Since our *MR* curve is steeper than in case of Lane (1999), the marginal benefits of higher investment to the lender in terms of required rate of return are lower for each level of capital. Hence, the effect of the wealth increase will be lower as well. The reason for this is similar to the logic outlined in Gurdgiev (2004, Chapter 4). With a higher degree of repudiation risk for all levels of investment, lenders require higher collateral on all projects. This is the direct effect of repudiation risk in Gurdgiev (2004, Chapter 4). At the same time, lenders are also aware of the adverse effects of the repudiation risk on moral hazard. Thus, they are willing to forego some of the returns in order to ensure that the entrepreneur adopts a high level of effort.

In cases 1 and 2, the rise in capital availability will be dampened by the negative effect of rising repudiation risk, as long as *ZZ* curve continues to restrict the solution space for capital. This effect is present in our model, but absent in both the Gertler-Rogoff (1990) model and its extension by Lane (1999).

Overall, the presence of the project-contingent repudiation risk acts to highlight the importance of exogenous controls on entrepreneurial activity and the ability of the entrepreneurs to raise financing. Lane (1999) established that in the presence of moral hazard, repudiation risk matters even for an economy not facing a binding borrowing constraint. In our model, the repudiation risk effects reach deeper. As shown in the discussion of cases 1 and 2 above, lax borrowing constraints continue to reduce economy's capital capacity, as in Lane (1999). However, lax repayment constraints are now associated with the binding effects of the repudiation risk as well. This happens whenever the marginal costs of capital on repudiation risk are relatively strong.

Our model goes further in terms of both intuition and applicability to the problem of resolving the dilemma of the shortage of capital flows between the OECD and the developing countries. As shown in Lane (1999), whenever repudiation risk applies in both states of nature, lending flows from North to South will be constrained by the symmetric nature of repudiation risk that amplifies moral hazard independently of the entrepreneur effort. However, in the 'good' state of nature, asymmetric repudiation risk or limited liability has no effect on the moral hazard. This implies that in the case corresponding to the asymmetric repudiation risk, neither corruption nor advancement of control institutions over the entrepreneurial activity, matter. The capital flows between North and South and within the North are thus indistinguishable in their response to the rate of return.

Yet, as the recent evidence suggests, as the global economic environment moves in favour of 'good' state realisation, so that $\pi(k) \rightarrow 1$, capital does not move as freely between the North and the South as within the North alone. This implies that capital flows in case of asymmetric repudiation risk remain dependent on the level of limited liability protection or the general ability of entrepreneur to prevent the appropriation of returns by the lenders. This is also consistent within the OECD economies with varying degrees of limited liability protection. Thus, during the IT-sector boom, when the standard anticipation of the repudiation risk liability accrued commonly to bankruptcy liquidations alone, lenders in some economies were reluctant to lend outside the personal guarantees that have effectively bypassed the limited liability clause of bankruptcy laws.

In contrast to the benchmark models, the above shows that when the repudiation constraint binds in the case of asymmetric repudiation risk (limited liability), our model captures these important stylised empirical facts.

2.2. Cases 4-5: Repudiation Risk Applying in Both States.

Next we consider case 4 (and in case 5 along the same lines) where $\phi_G > 0$, such that the repayment constraint binds in both states. This is the case of pure repudiation risk. Unlike in cases 1-3, where repudiation risk can be interpreted as the limited liability clause, here the risk accrues to both the case of a successful completion of the project and in the case of default due to the bad' state realisation.

In general, this case implies that $\mu = 0$, so that (4) holds at inequality and thus the private returns to the entrepreneur exceed the cost of borrowing and the incentive constraint does not bind. In this case, we can summarise the main equations of the model as follows:

MR curve equation (8a*)*

IC curve equation (8b)

ZZ curve $\alpha(k)\theta = \mathrm{Z}$ (9c)

The solution to the problem is given by:

$$\frac{\alpha(k_4)}{R}\left[\pi(k_4)\theta + \theta_B\right] + W = k_4 \qquad (10)$$

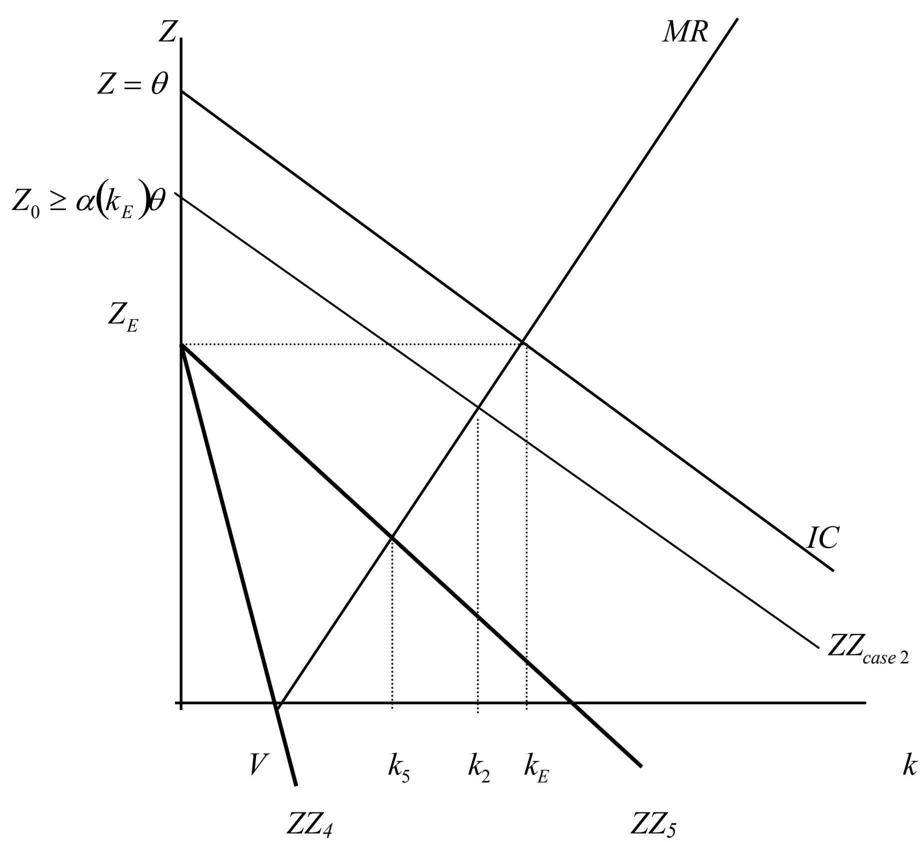
Note that the intercept for *MR* curve is given by $V = W + \frac{\alpha(k)\theta_B}{R}$, so that solving for intersection of *MR* and *ZZ* curves we have, as in Figure 3 below, that the level of capital investment available to the entrepreneur is just equal to her effective collateral.
Once again two sub-cases are possible depending on the relative magnitude of the marginal cost of capital in terms of repudiation risk.

Case 4. Strong repudiation risk implies that the entrepreneur will not be able to raise more than $k_{2A} = V$. For lenders, this implies that incentives to the entrepreneur to adopt high level of effort and to pay out the required return, in the case of a successful realisation, are too high relative to the risk-free rate. Thus lenders will opt to lend only to the amount of the effective collateral that is a decreasing function of the capital levels. In the limit, as the negative effect of capital levels on repudiation risk rises, the entrepreneur will have to self-finance the project.

The same logic applies in the case of **medium repudiation risk**. Since the rate at which capital available to the entrepreneur declines with risk depends on the marginal effect of capital levels on repudiation risk. Only the wedge between the good and the bad case payoffs $\theta = \theta_G - \theta_B$ prevents the complete collapse of the lending markets. In this scenario the level of capital is given by $k_4 = V + \frac{\alpha(k_4)}{R}\pi(k_4)\theta$, so that when $\theta \to 0$, $k_4 \to V$. This implies that only domestic lending markets operate, with foreign lending being completely shut down. The driving force behind this result is that here the foreign lenders face the possibility of symmetric repudiation risk (applicable in both states of nature), while domestic lenders may face only the limited liability risk (applicable in the bad state of nature alone). With repudiation risk being a strong determinant of the overall risk of investment, as in case 4, the firms are forced to either finance investment projects on their own (whenever V is the capital available to a firm internally), or via domestic markets (whenever V can be interpreted as the domestic value of the firm). This result is new to our model relative to both Gertler and Rogoff (1990) and Lane (1999) models.

Case 5. Weak repudiation risk effect on capital results in some borrowing in excess of the effective collateral. $k_4 = V < k_5$. Here, the incentives to adopt a high level of effort by an entrepreneur are increasing in capital outlay faster than the incentives to default due to higher repudiation risk. However, since the repudiation risk applies to both states of nature, the lenders will impose higher collateral demands on borrowers than in the case of asymmetric repudiation risk. As the result: $k_4 < k_5 < k_2 < k_1$.

Figure 3. Symmetric repudiation risk effect.



The graphical solutions for cases 4-5 are shown in Figure 3 above.

Hence, overall in case 4, an external lending solution cannot be attained. Instead, in case 4 we have a corner solution, $k_4 = V$ consistent with no lending in the international markets. This is consistent with Lane (1999) result for the symmetric repudiation risk case. However, in contrast with Lane (1999), even if the vertical intercepts of *ZZ* curves in our case and in the benchmark model coincide, so that $Z_0^{our} = Z_E \equiv Z_0^{GRL}$, the level of capital lending attainable in our economic environment will be below that attained in Lane (1999).

Conclusions.

This paper develops a comprehensive model of investment in the presence of the project-contingent repudiation risk and moral hazard. In a departure from the traditional literature on repudiation risk, the model proposes a link between the size of the project and the level of repudiation risk. We consider the case of economies that are characterised by an increasing risk of repudiation as a function of the capital outlay for the project. This allows us to focus on the case of economic environments that can be distinguished by the political protection favouring larger investment projects, so that the risk of repudiation increases with the project size. As argued in the introduction, in the presence of corruption and lax monitoring of the projects, large scale investments may be politicised to such a degree that investors may be precluded from collecting the payoffs to the projects. This possibility may arise either in the case of a symmetric risk or in case of state-contingent (asymmetric) risk.

Alternatively, as discussed briefly, the present framework allows for the consideration of scenarios where repudiation risk may be a decreasing function of capital outlay. In terms of economic environment, such a situation may arise whenever developed monitoring structures are in place to control entrepreneur payoffs for larger projects, but not for the smaller ones. It is important to reiterate here that our analysis directly extends to the possibility of considering the repudiation risk link to either capital outlay or to the degree of indebtedness of the entrepreneur. This property of the model is due to the linear relationship between the size of the debt that an entrepreneur undertakes and the size of the capital required for the project.

Likewise, we can view the project size- contingent nature of the repudiation risk as being synonymous with the monitoring cost. If the monitoring costs are increasing in the project size or the debt leverage assumed by an entrepreneur, such costs are fully correspondent to the case of a symmetric repudiation risk discussed here.

Using as a foundation Lane's (1999) analysis of the repudiation risk in the Gertler and Rogoff (1990) model, we consider two main groups of cases:

Cases 1-3: asymmetric state-contingent repudiation risk applying in 'bad' state of nature alone;

Cases 4-5: symmetric repudiation risk applicable in both states of nature.

Comparing these cases with the benchmark model, we show that in case of **repudiation risk being restricted to the 'bad' state of nature** alone:

- When marginal cost of higher capital outlay, in terms of an increase in repudiation risk, is below the marginal benefits of the associated higher probability of success, entrepreneurs are able to raise the level of capital that is qualitatively comparable to, yet quantitatively lower than in, Lane (1999).

- However, as the repudiation risk effect of capital outlay rises, the level of capital available to entrepreneur falls.
- The limiting case in the scenario of asymmetric repudiation risk is potential shutdown of lending markets for the strong effects case.
- In the medium risk case, the limiting effects of project-contingency of repudiation risk is to reduce capital availability relative to Lane (1999).

In the case of **symmetric repudiation risk**:

- Only a weak repudiation risk linkage to the size of the investment results in the operation of the credit markets.
- Strong and medium effects both yield shut down of the credit markets as both cases allow entrepreneurs to raise only internal funding for the projects.
- The reason for these effects is that in the case where repudiation risk is linked in both states to the level of capital, any appreciable degree of risk will trigger non-payment by the entrepreneur in both states. Thus, the moral hazard reducing effect of raising the probability of success, due to a higher level of investment, does not enter the lenders' consideration.

Thus overall, the model supplies intuitively plausible predictions that a stronger linkage between repudiation risk and investment levels will have a stronger effect on the required rate of return in order to provide incentives for lending. The repudiation risk effect thus magnifies the negative effects of moral hazard risk, while the project-contingent nature of repudiation risk strengthens the overall risk since both lenders and entrepreneurs are aware of the positive effects of the project size on the project risk.

At the same time, the above link places a greater emphasis on the lender role as the supplier of funding that raises the probability of the project success. Thus we have, in contrast with existing literature, the following results:

- State-contingent risk, applying in the bad state of nature alone, provides a binding constraint on borrowing, unlike in Lane (1999);
- Symmetric risk will lead to a shut-down of the credit markets whenever the marginal effects of the rising repudiation risk are stronger than the marginal effects of the increasing probability of success;
- Markets may fail (albeit in an extreme case) even in the case of asymmetric risk.

In so far as the present study endogenises the repudiation risk by linking the level of risk with the characteristics of the project itself, the model presented above offers an interesting case for the future analysis.

First, the study develops an explicit relationship between the testable hypothesis concerning the observable environment and the ex ante analysis of potential investment projects. It will be of interest and value to consider the validity of our theoretical predictions on the basis of empirical analysis. With this in mind, we can construct a proxy measure of the degree of repudiation risk linkage to the environment of the projects. We can then determine whether or not the size of investment projects arising in each environment is linked to the degree of repudiation risk exposure warranted by each environment.

Second, we can extend the model to consider the issue of bankruptcy liquidation and limited liability as a separate, asymmetric repudiation risk that can be compared against the general symmetric repudiation risk. Such risk can be measured, for example, by the rate of dividend and principal non-payment under general conditions (as opposed to the aggregate or individual 'bad' state realisations). The two types of repudiation risk, according to the predictions of our theoretical model, should imply varying degrees of exposure of each credit market to the possibility of failure. Thus countries with predominantly asymmetric repudiation risk will exhibit more developed and deeper lending markets relative to the economies with more dominant, symmetric risk considerations.

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Appendix 1. Mathematical Solutions.

Here we proceed to provide details of the mathematical solutions for the results shown above.

As discussed in the text, entrepreneurs maximise the expected consumption in the period following the initial investment in a project. The maximisation program is given by:

$$\max_{[k,b,Z_g,Z_B]} E_t C_{t+1} = \pi(k)[\theta_G - Z_G] + (1-\pi(k))[\theta_B - Z_B] + R[W + b - k] \quad (7a)$$

subject to

$$[\phi_G] \qquad \alpha(k)\theta_G \geq Z_G \quad (2a)$$

$$[\phi_B] \qquad \alpha(k)\theta_B \geq Z_B \quad (2b)$$

$$[\mu] \qquad \pi'(k)[\theta - Z] \geq R \quad (4)$$

$$[\gamma] \qquad W + b - k \geq 0 \quad (5)$$

$$[\psi] \qquad \pi(k)Z_G + (1-\pi(k))Z_B = Rb \quad (6)$$

First order conditions for optimisation are:

$$\pi'(\theta - Z) - R + \mu\pi''(\theta - Z) + \pi' Z\psi + \alpha'(\phi_G\theta_G + \phi_B\theta_B) = \gamma \quad (7b)$$

$$\gamma = (\psi - 1)R \quad (7c)$$

$$\pi[\psi - 1] = \pi'\mu + \phi_G \quad (7d)$$

$$(1-\pi)[\psi - 1] + \pi'\mu = \phi_B \quad (7e)$$

Cases 1-3. $\phi_G = 0$ and $\mu > 0$ which implies that the repayment constraint is satisfied at equality in the case of the 'good' state realisation, while the incentive constraint binds. As in Lane (1999) this implies that condition (6) holds at equality, while by equation (7e) we have that the repayment constraint is also binding in the 'bad' state. Then as in Lane (1999) the solution (k, Z) is given by the system of equations:

MR curve $$Z = \frac{R(k-W) - \alpha(k)\theta_B}{\pi(k)} \tag{8a}$$

$$b = k_t - W$$

IC curve $$Z = \theta - \frac{R}{\pi'(k)} \tag{8b}$$

ZZ curve $$\alpha(k)\theta = \mathrm{Z} \tag{8c}$$

By the assumption that repudiation risk is increasing in capital outlay, the *ZZ* curve is down-sloping. Since at *k=0*, all pledged returns are collected, the intersection for the *ZZ* curve is at the same point as in Lane (1999), i.e. $Z_0 = \alpha(0)\theta_B > Z_E$.

However, unlike in Lane (1999), the actual level of investment continues to depend in our case on the repayment constraint given by the *ZZ* curve. The reason for this is that in our model, while repayment is fully pledgeable (as in Lane, 1999), the repudiation risk link with the capital level creates a constraint on incentives for the entrepreneur to adopt a high level of effort.

It is straight forward to show that by equations (8b) and (8c), the slope of *ZZ* curve is steeper than the slope of the *IC* curve if and only if

$$\mathrm{mod}\left[\alpha'(k)\right] < \frac{R}{\theta\pi'(k)^2}\,\mathrm{mod}\left[\pi''(k)\right] < 1 \tag{A1}$$

where the last inequality arises from the concavity assumption on the probability function for the realisation of a 'good' state of nature. As the result of (A1), the graphic solutions for cases 1-3 follow.

To show that $k_E > k_3$, set *MR=IC* to get Lane (1999) solution:

$$\frac{R(k_E - W) - \alpha(k_E)\theta_B}{\pi(k_E)} = \frac{\theta\pi'(k_E) - R}{\pi'(k_E)}$$

and set *ZZ=MR* in equations (8a) and (8c) in order to get case 1 solution:

$$\frac{R(k_1 - W) - \alpha(k_1)\theta_B}{\pi(k_1)} = \alpha(k_1)\theta$$

Comparing the right hand sides of the preceding two equations evaluated at *k*, we have:

$$\frac{-R}{\pi'(k)} >,< \left[\alpha(k) - 1\right]\theta < 0$$

Hence, the separation point for cases 2 and 3 is:

$$\alpha(k) >,< 1 - \frac{R}{\theta\pi'(k)}.$$

The first inequality refers to the case when the repudiation risk has a weak effect on the investment level. Rearranging the first inequality:

$$1 - \alpha(k) < \frac{R}{\theta\pi'(k)},$$

which implies that in the case of weak repudiation risk effect, the share collectable privately by the entrepreneur, i.e. the private benefits to entrepreneur from defaulting, falls below the level of benefits from the lower moral hazard that is associated with rising capital investment levels. The second inequality refers to the case of a moderate repudiation risk effect, as discussed in the text, and can be interpreted as the opposite of the first case discussed above.

Cases 4-5 solutions trivially follow along the same lines, yielding equation (10) as in Lane (1999). The only caveat is that, setting *Z=0* in *ZZ* equation implies that $\alpha(k_0) = 0$ so that all investment projects will be self-financed at the level of capital outlay of *V*.