# International Lending with Increasing Returns and Moral Hazard

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**Abstract**

This paper examines the effects of increasing returns to investment on international lending and borrowing with moral hazard. Introducing increasing returns in a two-country general equilibrium model yields possible multiple equilibria and helps explain the possibility of capital flows from a poor to a rich country. I find that a borrowing country may need to borrow sufficient amounts internationally to reach a minimum investment threshold in order to invest domestically. I also show how the open economy equilibria interest rates can lie outside the interval of autarky rates.

**JEL Classifications**: D82, E22, E43, E44, F21, F34, F41

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**1. Introduction**

This paper models international lending and borrowing with increasing marginal returns to capital, in a setup characterized by the presence of moral hazard. I show how this environment can give rise to thresholds, multiple equilibria, perverse international capital flows, and interest rates that lie outside the interval of autarky rates. A small country set-up and a two-country case are examined. Asymmetric information and the possibility of capital flight, which create inefficient investment, are incorporated in the analysis. The model extends that of Gertler and Rogoff (1990), which only examines the case of diminishing marginal returns.

Increasing returns to capital continues to be an active research area given the empirical support it has garnered in recent studies. It is interesting to note, for example, that the 2008 World Development Report, when referring to agriculture emphasizes the importance of increasing returns. Thus, we read that although “many international and national investments in R&D have paid off handsomely, with an average internal rate of return of 43 percent in 700 R&D projects evaluated in developing countries in all regions,” in Sub-Saharan Africa investment was considerably lower in part because the “small size of many of these countries prevents them from capturing economies of scale in agricultural R&D … For these countries, sharply increased investment and regional cooperation in R&D are urgent” (p.14-15). The evidence, such as the above example, also suggests that with increasing returns, the initial returns are low.

Further, previous studies have suggested that there are increasing returns to infrastructure and manufacturing. Rodriguez (2008) finds evidence of increasing returns to manufacturing across nations. The empirical work on infrastructure and IT in the U.S. by Duggal, Saltzman, and Klein (1999, 2007) supports initial increasing returns. Fingleton and McCombie (1998) find evidence of increasing returns in EU manufacturing. Oliveira, Jayme, Jr., and Lemos (2006) find evidence of increasing returns in manufacturing in Brazil, and Park and Kwon (1995) find support for economies of scale in Korean manufacturing.

The literature on the effects of increasing returns to scale is vast, including the large literature on poverty traps. Rosenstein-Rodan (1943) popularized the idea that a “big push” was necessary for some countries to take advantage of economies of scale. Many theoretical studies have shown how a big push or collaborative effort is needed to move out of a poverty trap. Murphy, et al (1989) and Azariadis and Stachurski (2004) provide an extensive analysis. However, empirical tests of poverty traps have not substantiated the theory. Easterly (2006) finds that most poverty trap hypotheses are not robustly supported by the data. Rodriquez (2008) finds increasing returns to manufacturing, but does not find robust evidence for multiple equilibria. Although the evidence is debatable whether a big push of funds increases income per capita, the general belief is that a big push is necessary for some economies to get out of poverty traps. As described in Easterly (2006), 2005 was “the Year of the Big Push,” as there was an international effort to meet the eight Millennium Development Goals for improvements in social and economic indicators in developing countries by the year 2015, which has led to an emphasis on foreign aid.

Despite all this literature on increasing returns, studies of its effects on international lending and borrowing are conspicuous by their absence. Studies have tended to focus on explaining why we see increasing returns, such as human capital or institutional differences, but not many have actually modeled the effects of increasing returns on lending and borrowing. In one exception, Spiegel (1995) introduces increasing returns in a sovereign debt model and finds that the equilibrium credit constraint as a share of the capital stock is increasing in the capital stock, and increasing returns enhances the potential for long-term lending strategies. This paper’s setup differs from Spiegel, asymmetric information and uncertainty is introduced, and the focus is on equilibrium investment levels, perverse capital flows, and equilibrium interest rates. Here, increasing returns to capital yield thresholds along with the possibility of multiple equilibria, which is consistent with the previous increasing-returns literature.

Introducing asymmetric information between the lender and borrower, along with the possibility of capital flight, gives rise to a moral hazard problem. The issue of moral hazard has been discussed extensively in the literature on international lending and borrowing, and especially in regards to the IMF [see Atkeson (1991), Corsetti, et al (2006), Gertler and Rogoff (1990), and Lane (1999)]. Most of this literature, however, unlike the present paper, restricts attention to an environment with constant returns.

This paper is organized as follows. In section 2, I set up the model for a small open economy. I find that introducing increasing returns to investment, combined with the problem of moral hazard, helps to further explain why there might be suboptimal borrowing or lending. In section 3, I set up a two-country model and find that increasing returns may yield multiple equilibria and help explain why we could see capital flows from the poor to the rich country. In fact, contrary to statements in Gertler and Rogoff (1990), I show that under diminishing returns, funds must flow from the poor to the rich country as the capital account is liberalized. In section 4, I simulate the two-country model to help illustrate the results.[1] I also show how introducing initial increasing returns with free international capital mobility can lead to equilibrium interest rates that lie outside the interval of autarky interest rates. This stands in contrast to the standard result with diminishing returns, where equilibrium interest rates under capital mobility lie between the autarky levels. Section 5 concludes.

**2.1. Model for a small open economy**

To see the effects of increasing returns to scale on borrowing and lending, I use the model introduced in Gertler and Rogoff (1990).[2] I first look at a small country that faces the gross world interest rate $R^W$ (or $1+r^W$, where $r^W$ is the net interest rate). I will assume that the country is populated by entrepreneurs who live for two periods. They invest on date 1 and consume only on date 2. This allows us to focus on the investment story and abstract from the effects of consumption smoothing, without losing any major insights. I will assume the representative entrepreneur is risk neutral with the linear utility function:

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[1] For a good discussion on why computations are useful, see Judd (1997)

[2] I use a slightly simpler version from the textbook of Obstfeld and Rogoff (1996).

$$U(C_1, C_2) = C_2 . \tag{1}$$

In the first period, the entrepreneur receives an exogenous endowment of $Y_1$, which can be either invested abroad at the world riskless interest rate $R^W$ or invested in a risky domestic firm. Investment in the domestic firm at level *I* yields an output $Y_2$ distributed as follows:

$$Y_2 = \begin{cases} Z \text{ with probability } \pi(I) \\ 0 \text{ with probability } 1-\pi(I) \end{cases} \tag{2}$$

I assume $\pi'(I) > 0$; however, unlike Gertler and Rogoff (1990), I will not assume $\pi''(I) < 0$ for all levels of investment. I look at the case where initial levels of investment have increasing returns to scale. We should, however, eventually expect the marginal returns to be diminishing after some investment level. The contribution of this paper is to look at the implications that initial increasing returns to investment may have on international lending and borrowing with moral hazard. The assumption in this model will be that the source of the increasing returns is internal to the firm, but alternatively one can view the returns as external and assume that the borrower is the government and social planner.

The entrepreneurs would like to maximize the present value of their expected return on their home investment minus the investment, i.e.,

$$-I + \frac{\pi(I)Z}{R^W} . \tag{3}$$

The first-order condition of this maximization problem is

$$\pi'(I)Z = R^W . \tag{4}$$

For the case of diminishing returns to investment, some investment level $\bar{I}$ is the unique solution to the maximization problem. With initial increasing returns to investment, we can have two investment levels that satisfy the first-order condition, where the higher of those two levels achieves the maximum value from domestic investment. Note that in the diminishing-returns model it is assumed $\pi'(0)Z > R^W$ to ensure that a positive level of investment is efficient under symmetric information. I assume that the initial returns are low $\pi'(0)Z < R^W$, which may be more realistic, especially in big projects such as infrastructure, and which also explains why the poorest countries are not getting enough investment in such projects (such as the R&D example mentioned earlier). A positive level of domestic investment can still be assured under symmetric information if the marginal returns eventually surpass the world rate enough to make up for the initial low returns.

Figure 1 shows the expected marginal return on domestic investment, $\pi'(I)Z$, and the return from investing in riskless world securities, $R^W$. I assume that $\pi''(I) > 0$ for $I < \tilde{I}$ and $\pi''(I) < 0$ for $I > \tilde{I}$, where I define the investment level labeled $\tilde{I}$ as the investment level where the marginal returns to domestic investment switch from increasing to decreasing. I also assume $\pi'(\tilde{I})Z > R^W$, to guarantee some investment levels in the domestic firms yield higher marginal rates of return than the world rate. While I placed the intercept for the domestic returns at the origin, a country with some infrastructure or industry buildup would have an intercept nearer to the world rate. The two investment levels $\underline{I}$ and $\overline{I}$ are where the expected return to domestic investment equals the riskless world return. As will be shown in the following sections, the efficient investment level will not be achieved under asymmetric information, and when combined with increasing returns, then little or no domestic investment may occur.

**2.2. Incentive Compatibility**

Before solving for the possible loan contracts, we must define the incentive constraints of the borrowers and lenders. Define *L* as the amount of funds that the domestic entrepreneur may secretly lend abroad instead of at home, and *D* as the amount of the loan to the domestic entrepreneur. I define the domestic individual's period 1 finance constraint as

$$I + L = Y_1 + D, \tag{5}$$

where

$L \geq 0$ and $D \geq 0$.

If foreign lenders are risk neutral and operate in a competitive market, they will earn the expected return of $R^W$ on any loan to an entrepreneur. In the "bad" state of nature, where $Y_2 = 0$, no repayment would be possible by the entrepreneurs. Therefore, promised payments by the entrepreneurs have to be of the state-contingent form $P(Y_2)$, where $P(0) = 0$ and $P(Z)$ is determined by the lender's zero profit condition:

$$\pi(I)P(Z) = R^W(I - Y_1). \tag{6}$$

The zero profit condition states that the expected payment will give the lenders a return of $R^W$ on their loan, given the entire amount of the loan is domestically invested by the entrepreneurs. As I will discuss later, in an equilibrium contract, we would expect that the amount of secret lending by the entrepreneurs, *L,* will be equal to zero.

If domestic investment equals $\bar{I}$, this would be the first-best borrowing contract. In the case with initial increasing returns, $\bar{I}$ is the higher investment level which solves $\pi'(I)Z = R^W$. If there is asymmetric information, we will see that the borrower will not be able to commit credibly to an investment of $\bar{I}$. Alternatively, a lower investment level $\underline{I}$ also satisfies the first-order condition, but the borrower is making a lower marginal return than $R^W$ on all of the domestic investment below $\underline{I}$. Since the marginal returns begin low, but then exceed the world interest rate over some range of investment, domestic investment must be large enough in order for the total return to exceed the return from putting all the funds in the riskless world asset.

As in Gertler and Rogoff (1990), I will assume the following information structure: The borrower's first-period endowment $Y_1$, gross borrowing *D*, and second-period output $Y_2$, are directly observed by the lender. However, the lender does not directly observe the first-period investment, $I$, or the amount of funds, *L*, that the entrepreneur may secretly lend abroad in period 1. The borrowers don't choose $I$ and *L* until the lenders set the amount and terms of the loan, *D* and $P(Y_2)$. If the "bad" outcome occurs, the lender cannot prove that the borrower did not use the entire amount of the loan for domestic investment.

Given the state-contingent payment plan and the possibility of secretly acquiring foreign assets, the borrowers will try to maximize expected second-period consumption:

$$EC_2 = \pi(I)[Z - P(Z)] + [1-\pi(I)][0 - P(0)] + R^W L$$

$$= \pi(I)[Z - P(Z)] - [1-\pi(I)]P(0) + R^W (Y_1 + D - I).$$

The first-order condition for an interior maximum with diminishing returns is given by

$$\pi'(I)[Z - P(Z) + P(0)] = R^W. \quad (7)$$

Note that if the debt payments were the same in both the good and the bad state, there would be no moral hazard problem since the borrowers would have the incentive of choosing the efficient level of investment, which satisfies $\pi'(I)Z = R^W$. However, since the "bad" state yields nothing, the borrowers cannot repay, so we set $P(0) = 0$. Recall that the optimal contract under commitment is $P(Z) = \dfrac{R^W(\bar{I} - Y_1)}{\pi(\bar{I})}$ , which is positive if $Y_1 < \bar{I}$. Since expected repayment is positive at the efficient level of investment, the marginal return $\pi'(I)Z$ must be must be higher than the world rate $R^W$ in order for the borrower to get a net marginal return of at least $R^W$. Therefore, if offered a loan to invest the efficient amount, the borrower will instead choose to invest some amount less than the efficient investment level $\bar{I}$ in the domestic economy. The intuition is that the lender agrees to share the risk of a bad outcome whenever *P*(Z) is different from *P*(0), and the borrower has less incentive to invest in the good outcome and secretly lends some money abroad to earn the sure return $R^W$.

Under increasing returns to investment, there can be two investment levels for a given expected repayment that sets the net marginal return to the borrowers equal to the world interest rate. If investment happened to be at the point where the net marginal return equals the riskless interest rate, then the borrower will be indifferent between investing domestically and lending at the world rate. However, in this setup the borrower determines how much to invest, and if the repayment is low enough to give the borrower a net marginal return equal to the world rate, the repayment may still be too high to give the borrower a net total return that would exceed what the borrower could have made lending everything at the world rate. Since the marginal domestic product starts low, $\pi'(0)Z < R^W$, in order for the borrower to be willing to invest the funds domestically, there must be a sufficient range and magnitude at which the expected net marginal returns exceed the world rate, $\pi'(I)[Z - P(Z)] > R^W$, to get an expected net return from investing domestically that is higher than investing everything at the world rate,

$$\pi(I)[Z - P(Z)] \geq IR^W. \tag{8}$$

Assuming the domestic marginal returns do sufficiently exceed the world rate enough such that there exists a positive repayment amount that the borrowers would be willing to accept, there is no guarantee that such a repayment would be acceptable to the lenders. Sufficiently poor countries may not be able to contract for funds since the repayment required by the lenders in the good state may be too large to meet the condition in equation 8. If the borrower's income is large enough, we can solve for contracts that are compatible with both the incentives of the borrower and the lender, which is done in the next section.

**2.3. Equilibrium Incentive-Compatible Contracts**

We can now solve for the possible incentive-compatible contracts, where both the borrowers and the lenders expect to earn a return that will give them at least the riskless return, $R^W$. From the borrower's first-order condition and equation 8, we can write the incentive compatibility constraint as

$$P(Z) \leq Min[Z - \frac{RI}{\pi(I)}, Z - \frac{R}{\pi'(I)}]. \tag{9}$$

The incentive constraint says that the expected repayment cannot be too high such that the borrower could have made a higher return from secretly lending at the world rate, nor can the repayment be too high such that the net marginal return is lower than the riskless world asset. Unlike the model with diminishing returns to investment, as explained below, we have an incentive compatibility constraint that is increasing for low levels of investment and decreasing for higher levels of investment. Graphically, this is shown in Figure 2, where IC(1) is the first condition that must be satisfied in the incentive constraint, while IC(2) is the second. The portion that satisfies both conditions is the incentive constraint.

If the domestic marginal product starts out lower than the riskless world rate at low investment levels, then the borrower will invest domestically only when it can invest enough funds to get a sufficient amount of higher marginal returns to be worth it. The borrower's incentive constraint will intersect the horizontal axis in Figure 2 when the expected domestic output equals the total riskless return, $\pi(I)Z = IR^W$, since the borrower will not agree to any positive repayment for any investment lower than this level under increasing returns. Once the expected domestic output exceeds the total return from investing in the riskless asset, the risk-neutral borrower would be willing to make a positive repayment. Therefore, the slope of the incentive constraint is initially positive.

The expected repayment acceptable to borrowers, $\pi(I)P(Z)$, will increase as long as the gap between the expected output, $\pi(I)Z$, and the return on the riskless asset, $IR^W$, increases. This gap will be at its largest when the marginal domestic return equals the world interest rate (the higher $I$ that solves the equation), $\pi'(I)Z = R^W$. The acceptable contracted repayment to the borrowers in the good state, $P(Z)$, will increase as long as the net marginal return, $\pi'(I)[Z - P(Z)]$, exceeds the world rate $R^W$. Solving the first condition of the borrower's incentive constraint in equation (9), $Z - \frac{R^W I}{\pi(I)}$, for a maximum, we would find that the acceptable repayment is highest when $I = \frac{\pi(I)}{\pi'(I)}$. At this investment level, $P(Z) = Z - \frac{R^W}{\pi'(I)}$, which is the second incentive constraint condition, where the expected net marginal return equals the world interest rate. For investment levels above this level, the borrower's incentive constraint is now the second condition in equation (9).

While some higher repayment than specified in the second condition of the incentive constraint may still give the borrower a higher net total return than lending at the world rate, the borrower will not repay such an amount that would make the net marginal return on domestic investment less than the risk-free interest rate. This second condition of the incentive constraint is increasing under increasing returns and decreasing under diminishing returns. If the borrower can invest enough domestically such that the repayment is lower in the second condition, it must be the case that there is decreasing returns to scale. The expected net total return can be thought of as the average return given a repayment, which will only catch up to the marginal return if the marginal return declines.

Intuitively, the second condition of the incentive constraint in Figure 2 intersects the horizontal axis at $\underline{I}$ and $\bar{I}$. Any domestic investment level below $\underline{I}$ or above $\bar{I}$ will provide a marginal return less than the return in the world market, so no repayment would be acceptable for a borrower. The first condition of the incentive constraint, IC(1), intersects the horizontal axis when the expected output equals the expected return that could be made from investing everything in at the riskless rate, $\pi(I)Z = RI$. The first intercept of IC(1) comes at a higher investment level than the first intercept of IC(2) since the total return from investing in the domestic economy will not exceed the amount that could be made from lending everything at the world rate until the domestic marginal returns have sufficiently exceeded the world interest rate. The second horizontal intercept of IC(1) comes at higher investment level than the second intercept of IC(2) since the borrower may still expect an overall positive return even if for some range of investment the marginal return did not exceed the riskless world rate.

In Figure 3, the incentive constraints of the borrower and lender are drawn. The zero-profit condition of the lenders, $P(Z) = \dfrac{R^W(I - Y_1)}{\pi(I)}$, intersects the horizontal axis at $I = Y_1$. If investment equals the endowment income in equilibrium, then there is no borrowing or lending, so there would be no repayment. Once investment is greater than the endowment, we would see some positive amount of repayment necessary for the zero-profit condition to hold. As debt initially grows, the amount of the repayment must increase since the lender must get repaid some positive amount in order to break even. Therefore, the slope of the zero-profit condition must initially be positive. Under diminishing returns, it can be shown that it will always have a positive slope. In Figure 3, the zero-profit condition is drawn with a positive slope.

However, if there are some initial increasing returns, then the slope of the zero-profit condition may actually be negative under some range of investment levels. If the marginal returns increase high enough, then it is possible that the additional debt increases the probability of the good state enough such that the repayment required to break even will decrease. To see this, if we calculate the first derivative from the zero-profit condition, $\frac{\partial P(Z)}{\partial I}$, we can find that it will be positive if $\pi(I) > D\pi'(I)$, which is not necessarily true under increasing returns to scale. What this means is that it is possible that an increase in loans to the borrower may actually decrease their real debt since the borrowers can be allowed to repay less because of the decrease in uncertainty that the investment will be successful.

In addition, given the slope of the borrower's incentive constraint, even without a dip in the zero profit condition, it is possible that the borrower may not be willing to agree to repay an acceptable amount to the lenders at some low amount of debt, but at a higher level of debt the borrowers and lenders may achieve an incentive-compatible contract. This case is shown in Figure 3. While a dip in the zero-profit condition is possible if we assume the income is low enough, there is no guarantee given such parameters that the zero-profit condition will ever allow for a repayment that is low enough for the borrowers to accept. With a sufficiently high income, a contract may be possible between the borrower and lenders, but the zero-profit condition may not have any negative slope if it starts at an income level where the increasing returns are exhausted. In Figure 3, the zero-profit condition is drawn given a sufficiently high income where there is no range at which the slope is negative.

In Figure 3, the endowment income of the borrower (where ZP equals zero) is not sufficient to make domestic investment worthwhile (where IC equals zero) without any loans. For a small amount a debt, the borrower would still not invest domestically, which would create the bad domestic outcome and no repayment. For a large enough debt, such that investment can reach the borrower's incentive constraint, the borrower would be willing to invest domestically if the promised repayment in the good outcome is low enough. The lenders will agree to the contract if the expected repayment, $\pi(I)P(Z)$, gives them at least the riskless rate. In Figure 3, the borrower and lender can agree on a loan that leads to investment between $\underline{I}^*$ and $\bar{I}^*$. The largest loan possible in this example is one that leads to the investment level of $\bar{I}^*$, which will be the equilibrium under no other constraints.

In the example in Figure 3, the only feasible contracts are where the zero-profit condition of the lenders meet the first condition of the incentive constraint of the borrowers (see IC(1) in Figure 2). This says that in equilibrium, the borrowers are investing domestically and getting marginal product that is not only higher than the world interest rate, but if the repayment is included, the net marginal return is still higher than the riskless interest rate. This possible result differs than what can happen if only diminishing returns were assumed (and higher initial returns), where the borrowers would only be concerned about the net marginal return on the additional investment and not the expected net overall return from the investment. Where investment equals $\bar{I}^*$, repayment that sets the net marginal return equal to the world interest rate would be at a higher repayment than the repayment on the incentive constraint in Figure 3, which can be seen in IC(2) in Figure 2. If investment was at $\bar{I}^*$, then the borrowers would be willing to accept a higher repayment at the margin, but since the borrowers do not have to invest anything domestically, they would not accept any repayment that would on average give them a lower net return than what they could have made lending at the world rate. For investment above $\bar{I}^*$, the repayment that the lenders need in order to break even exceeds the amount that the borrower would be willing to make, even though the amount that the borrower would be willing to repay increases. Therefore, with initial increasing returns, a sufficiently poor country may get less debt, invest less, and have a higher domestic marginal product than compared to the case with only diminishing returns.

A larger endowment income may shift the ZP curve to where it only intersects the IC curve on the IC(2) portion. In this case, the borrower will accept a repayment that sets the net marginal return equal to the world interest rate. A higher repayment may still give the borrower an expected positive net overall return, but the borrower could benefit more by secretly lending any funds that allow for investment to exceed the point where the net marginal return equal the riskless rate. The lenders, therefore, would not be willing to lend any amount above the point where the two curves intersect. This result is similar to the case where only diminishing returns to scale is assumed. If the endowment income is much smaller than the example in Figure 3, then the lenders and borrowers cannot agree on any loan amount. This differs from the diminishing returns case, where initial returns are high and there will always be some amount that the two parties could agree on.

We can also see that in an equilibrium that yields a contract, the borrowers will not secretly lend any amount at the world rate. As long as the contract is incentive-compatible for both the lenders and borrowers, there will be no capital flight. If the borrower chose to secretly lend abroad, then it must mean that the promised repayment in the good state was too high to invest all the loans domestically. This would mean that the repayment and investment schedule was not on the incentive constraint of the borrower, and hence not an equilibrium contract.

## 3. Two-Country Equilibria with Increasing Returns

### 3.1. The Model and Equilibrium

In this section, I will setup the two-country model as in Gertler and Rogoff (1990), but I will introduce initial increasing returns to scale. We will see how introducing increasing returns to scale can further explain the possibility of capital flows from the poor country to the rich country. In fact, I will show how capital must flow from the rich country to the poor country under diminishing returns as we go from autarky to free international capital flows in this model. With increasing returns to scale, we may observe capital flowing from the poor country to the rich country, as in capital flight from the Southern cone.

Assume two countries, Rich and Poor, have equal populations. In each country, a fraction *s* of the population are savers, and 1-*s* are entrepreneurs. The savers can diversify their portfolio and assure themselves of a riskless return of $R$, which I will solve for in this section. In the Rich country, both entrepreneurs and savers have an endowment of $y_1^r$, while in the Poor country they have an endowment of $y_1^p$. Both countries have identical preferences and technologies. I assume that individuals in the Rich country have a higher endowment, $y_1^r > y_1^p$. As in the small country case, I define the utility function as $U(C_1, C_2) = C_2$, so all of the first-period income will be invested.

If there were no asymmetric information, then we would expect the investment levels in the Rich and the Poor countries to be governed by the first-order conditions, $\pi'(I^r)Z = R^r$ and $\pi'(I^p)Z = R^p$. Under full information we would have the optimal level of investment for both countries, $\bar{I}^r = \bar{I}^p$. The world interest rate would then be equal the common expected marginal product of capital,

$$\pi'(\bar{I}^r)Z = \pi'(\bar{I}^p)Z = \pi'\left[\frac{y_1^r + y_1^p}{2(1-s)}\right]Z \tag{10}$$

where the investment levels are per entrepreneur. Intuitively, if the income will flow to the country yielding the highest rate of return, and the countries' have the same technology with eventual diminishing returns, then we would expect half of the world income to be invested by entrepreneurs in one country and the other half to be invested by the entrepreneurs in the other country.

Under the full-information case with only diminishing returns, savings cannot flow from the Poor country to the Rich country as we go from autarky to free international capital flows. If savings did flow from the Poor country to the Rich country, then it must have meant that the Poor country had a lower marginal product under autarky. However, this means that the initial endowment of the Poor country per entrepreneur must have been greater than the efficient level of investment per entrepreneur, or $\frac{y^p}{1-s} > \frac{y^p + y^r}{2(1-s)}$. This inequality simplifies to $y^p > y^r$, which is a contradiction. In the efficient outcome under full information and diminishing returns, savings must flow from the Rich to the Poor country.

However, the efficient outcome will be distorted when I introduce moral hazard with state-contingent repayment plans that have different values for the different states. We would then expect a poor country that has to borrow more to reach $\bar{I}$ would have a more severe moral hazard problem than a rich country, given that it has to pay more in the good outcome, and it would be given a contract that yields less investment than a rich country. By introducing initial increasing returns, we will see that this inefficiency can be worse. With increasing returns, the moral hazard problem could create an even bigger investment gap between the Poor and the Rich country than if there were only diminishing returns. When entrepreneurs of the rich country have the advantage of not having to borrow as much (or pay back as much) as the entrepreneurs of a poor country for a given level of investment, the rich country has a less severe moral hazard problem since the difference in repayment in the two states of nature is not as great. The rich country can then contract for more funds that leads to more investment, and with increasing returns get a higher rate of return, which leads to even more funds and investment and a greater gap in investment levels between the two countries.

As in Gertler and Rogoff (1990), I will assume both $y_1^r < \bar{I}^r$ and $y_1^p < \bar{I}^p$ in equilibrium, so entrepreneurs in both countries must be financed by the savers to achieve the first-best equilibrium. In this two-country general equilibrium model, all the income will be invested. The question of this section is how the income will be distributed between the two countries, and how will the introduction of initial increasing returns to scale can affect the investment gap between the two countries. I will now set up the two-country model and show that introducing increasing returns can explain the possibility of savings flowing from the poorer to the richer country.

As in the small-country case, under asymmetric information, the contracts that are offered to the entrepreneurs must satisfy their incentive-compatibility constraints. In this two-country setup, where the world rate is endogenous, the borrowers are concerned with the incentive constraints

$$P(Z)^r = Z - \frac{R^r}{\pi'(I^r)} \text{ and } P(Z)^p = Z - \frac{R^p}{\pi'(I^p)},$$

which is IC(2) in the small country case. The first condition of the incentive constraint in the small country case is not applicable here since the world rate is endogenous and cannot be taken as given when considering the total investment. As in the small country case, the lenders face the zero-profit conditions

$$P(Z)^r = \frac{R^r(I - y_1^r)}{\pi(I^r)} \text{ and } P(Z)^p = \frac{R^p(I^p - y_1{}^p)}{\pi(I^p)}.$$

I can solve for $R$ by setting the borrower's incentive constraint and the lender's zero-profit condition equal to each other. For the Rich country (and a parallel solution for the Poor) we have,

$$R^r = \frac{\pi'(I^r)Z}{1 + \frac{\pi'(I^r)(I^r - y_1^r)}{\pi(I^r)}}. \tag{11}$$

This is the same equation as in Gertler and Rogoff (1990); however, with the introduction of increasing returns to investment, we could get different possible outcomes in regards to the equilibrium investment level.

Graphically, the investment levels which yield the same returns from the two countries are shown in Figure 4. The curves labeled $R^r = R^p$ are investment levels where the risk-free interest rate for the Poor and the Rich country are equal. The IS curve, with a slope of negative one, is where all the income is invested. Point **C** is the efficient point, where $I^r = I^p$. An equilibrium where investment is occurring in both countries will be where the interest rates were equal. If the interest rates were not equal, then we would expect savings to flow to the country with the higher interest rate.

We see from Figure 4 that we have two separate curves that show where the interest rates are equalized between the countries, $R^r = R^p$. With initial increasing returns and then decreasing returns, high levels of investment by the Rich country can give a return that is the same as low levels of investment by the Poor country, and vice versa. Given the two curves, we have three possible interior equilibria, points **A**, **B**, and **D**. These points are where all the income is invested and where both countries have the same interest rate. As will be clear below, the more interesting $R^r = R^p$ curve is the upper one for investment levels $I^r, I^p > y_1^p$ , and the more plausible equilibrium in our setup is at point **B**.

When the entrepreneurs in both countries can finance their investment without relying on the savers, we should expect the rate of return for the Rich country to be equal to the Poor country for a given investment level. Since there is no repayment required when $I < y_1$, the expected return to investment in each country would simply be $\pi'(I)Z$. Therefore, we have $R^r = R^p$ at $I^r = I^p$ when $I^r, I^p \le y_1^p$. Now focusing on the upper $R^r = R^p$ curve, when investment levels are above the income of the entrepreneurs of the Poor country, the Rich country will have a higher net expected rate of return for each given investment level. The Poor country has a lower net expected rate of return because of the repayment they must make in the good state of nature, and the corresponding interest rate will be lower in autarky in the Poor country. The equilibrium interest rate sets the repayment equal between the borrower and lender as in equation 11. Looking at the $R^r = R^p$ curves in Figure 3, we would expect to see a jump from the lower curve to the higher curve as investment levels surpass $y_1^p$. When investment levels initially surpass $y_1^p$, the entrepreneurs of the Poor country must borrow money to invest, and this will result in a relatively lower net expected rate of return since they now must repay the lenders. So for the investment levels, $y_1^p \le I < y_1^r$, we are comparing an expected rate of return of $\pi'(I^p)Z$ for the entrepreneurs in the Rich country and $\dfrac{\pi'(I^p)Z}{1+\dfrac{\pi'(I^p)(I^p-y_1^p)}{\pi(I^p)}}$ for the entrepreneurs of the Poor country.

As investment surpasses $y_1^H$ for the Rich country, the entrepreneurs have to start borrowing and the expected riskless rate of return for the Rich country is $R^r = \dfrac{\pi'(I^r)Z}{1+\dfrac{\pi'(I^r)(I^r-y_1^r)}{\pi(I^r)}}$. In order for the expected rate of return for the Rich country to equal the expected rate of return for the Poor country at $I^p = y_1^p$, the returns should fall in the Rich country. If the returns are increasing at $I^p = y_1^p$, then there could be a large investment gap between the two countries by the time the rate of return of the Rich country returns to the level it was at when $I^r = I^p = y_1^p$. This is the gap between the two $R^r = R^p$ curves at $I^p = y_1^p$. On the other hand, if there were diminishing returns from the start, then there would be no discontinuity, simply a gradual continuous increase in the difference of the investment levels along a single $R^r = R^p$ curve in the range $y_1^p \le I < y_1^r$.

Under increasing returns, as we look at investment levels for the Poor country above $y_1^p$, we would expect to see the investment gap between the two countries to decrease, which is represented by a dip in the upper $R^r = R^p$ curve. We should see the investment gap decrease because the rate of return for the Poor country is increasing and the rate of return for the Rich country is decreasing at the higher investment level, so a decline in $I^r$ would increase $R^r$ to match the increase in $R^p$ in the Poor country.

In Figure 4, the IS line represents the point where investment equals savings, $\dfrac{y_1^r + y_1^p}{1-s} = I^r + I^p$. Since all income will be invested according to our utility function (1), the equilibrium should end up on that line. Because of the moral hazard problem, we would not end up at the efficient point **C**, where the investments levels equal to each other (note: $\frac{\partial R}{\partial y_1}$>0 for a given level of investment, so for the same investment level the richer country would have a higher marginal return at the efficient point). Point **B** seems to be the equilibrium with the most intuitive appeal. As pointed out earlier, until $I > y_1^p$, the relevant curve is the lower $R^r = R^p$. Then we jump to the upper curve until all the savings are invested. This would leave us at point **B**. At this point, we see there is more investment in the richer country, and possibly savings are flowing from the poor country to the rich country. Points **A** and **D** are also possible equilibria since the returns are equal at those points, and all income is invested, but the mechanism at which we get to those levels is not as intuitive.

Increasing returns to investment may create a greater investment gap between countries compared to decreasing returns because of the jump from the lower to the upper $R^r = R^p$ curve at $I = y_1^F$. In fact, it is possible that no savers will acquire securities from the poor country if the jump on the upper $R^r = R^p$ curve reaches the IS curve. This would happen if all of the income was invested before the rate of return of the Rich country returned to the rate of return of the Poor country when $I^r = I^p = y_1^p$. This would depend on the specified probability function $\pi(I)$ and its marginal return $\pi'(I)$. While diminishing returns results in an investment gap because of moral hazard, introducing initial increasing returns could create a larger gap and help further explain why we see a difference in investment levels between rich and poor countries.

Not only can increasing returns create a bigger gap in investment levels between the rich and poor countries, it can also lead to capital flows from the poor to the rich countries. With diminishing returns, we cannot have capital flows from the poor to the rich countries as we move from autarky to free international capital flows, and this is shown in the appendix.

**3.2. Equilibrium Interest rates**

We are now in position to show that introducing increasing returns can lead to equilibrium interest rates that lie outside the autarky levels for the Poor and Rich country. We would normally expect the equilibrium interest rate to lie within the interval between the autarky interest rates. To show that with increasing returns the equilibrium interest rate(s) can fall outside the interval between the autarky interest rates, it suffices simply to provide an example. I do this in section 4.

Under diminishing returns, the equilibrium interest rate with free international capital flows must lie in the interval between the two autarky interest rates. From equation 11, we can find $\frac{\partial R}{\partial I} < 0$. If one country has a higher *R*, savings will flow to that country, and it will lower *R*. I just showed in the previous section that under diminishing returns, the richer country will have a lower *R*. Therefore, under diminishing returns, as we go from autarky to free international capital flows, savings would flow from the rich to the poor country. The poorer country's interest rate would then decrease and the richer country's interest rate would increase until the rates were equal. Hence, it must be that in equilibrium the interest rate will lie between the autarky levels.

To see a clearer picture of the effects of introducing initial increasing returns to investment, we can look at a numerical example. In section 4 we will look at a simulation by specifying a probability function that satisfies all the assumptions and requirements stated in the beginning of this paper. We will then go through an example of the two-country model. I will then show how the equilibrium interest rates with free capital mobility and increasing returns can lie outside the autarky rates.

## 4. A Simulation

### 4.1. The Two-Country Case

As a first step, I will specify a probability function $\pi(I)$ that has initial increasing returns and then decreasing returns, while always assuming $\pi'(I) > 0$. We should also at the same time give a value to the good state, *Z* , so we can get the rate of return for the entrepreneur. For simplicity, set $Z = 2$. For ease of exposition, the relevant investment levels would then be in the range $0 \leq I \leq 2$ , since the value Z is known, and no investment should exceed *Z* (otherwise an entrepreneur would be willingly investing an amount with no possibility of a return higher than his investment). An example of a probability function that satisfies all the properties for the investment values $0 \le I \le 2$ is $\pi(I) = \frac{1}{\sqrt{2}} I^{\frac{1}{I}}$.

To illustrate my results in the two-country general equilibrium, I can graph the rates of return for each country and see if it implies a graph similar to Figure 4. To better understand where the graph in Figure 4 comes from, I can decompose it by drawing three curves, $\pi'(I)Z$, $\frac{\pi'(I^r)Z}{1+\frac{\pi'(I^r)(I^r - y_1^r)}{\pi(I^r)}}$, and $\frac{\pi'(I^p)Z}{1+\frac{\pi'(I^p)(I^p - y_1^p)}{\pi(I^p)}}$. As stated earlier, when $I \le y_1$ , then the entrepreneurs are not borrowing any funds from the savers in order to finance their investment, so there is no repayment and the net return on investment is $\pi'(I)Z$. Once $I \ge y_1$, the entrepreneurs have to borrow from the savers, which means the contracts must satisfy both the incentive constraints of the borrower and the zero-profit conditions of the lender. Therefore, we have $R = \frac{\pi'(I)Z}{1+\frac{\pi'(I)(I - y_1)}{\pi(I)}}$ in equilibrium for a country whose entrepreneurs must rely on the savers.

In Figure 5, I graph the interest rates for each country, assuming the entrepreneurs in the Rich country have an income of $y_1 = 0.6$, while the entrepreneurs in the Poor country have an income of $y_1 = 0.3$. The interest rates of the two countries are the same for each investment level below 0.3, which is the income endowment of the Poor entrepreneurs. As investment surpasses 0.3, we see that the Rich country has a higher rate of return. Savings would then flow towards the Rich country until the rate of return of the Rich country returns to the level of the Poor country.

In this example, the rate of return of the Rich country does not return to the same level as the Poor country at $I = 0.3$ until investment in the Rich country reaches 1.28 per entrepreneur. This explains the jump that we explained in Figure 4 from the lower to the upper $R^r = R^p$ curve. As investment in the Poor country initially increases from 0.3, we see that the interest rate goes up, and an equivalent interest rate for the Rich country would be accompanied by an investment level of a little less than 1.28. This is why we see a small dip in Rich investment in Figure 4 after the jump to the upper $R^r = R^p$ curve. Also, as the Poor increases investment from 0.3, the higher interest rate of the Poor country can be achieved by lower investment levels of the Rich country, which explains the lower $R^r = R^p$ curve in Figure 4. Eventually, the investment gap for a given interest rate starts to converge because of decreasing returns to investment. In equilibrium we are looking at where all the income is invested, and where the risk-free interest rates are equal (if an interior solution). The IS curve in Figure 4 depends on the amount of savers and entrepreneurs.

By introducing increasing returns to scale, we see by the jump in Figure 4, or by the large gap in Figure 5, that it could potentially produce an even larger difference in investment than if we only assumed decreasing returns to scale. We see in Figure 5 that introducing increasing returns to scale creates an initial larger advantage for the Rich country than if we just assumed decreasing returns to scale. And as I explained earlier, we can actually get savings to flow from the Poor to the Rich country.

**4.2. Equilibrium Interest Rates with Increasing Returns**

I can show by example that the equilibrium interest rate with free international capital flows can lie outside the interval between the autarky interest rates. Using the same setting as before, I will assume that the individuals in the Rich country have an income of 0.6, while the individuals in the Poor country have an income of 0.3. I will also set the proportion of savers to be 0.42. We can now calculate autarky investment per entrepreneur, $\frac{y_1}{1-s}$, for the Rich country, $I_A^r = 1.034482$, and the Poor country, $I_A^p = .517241$.

We can now solve for the autarky risk-free interest rate by plugging the autarky investment levels into the equation $R_A = \dfrac{\pi'(I)Z}{1+\dfrac{\pi'(I)(I-y_1)}{\pi(I)}}$. For the rich country we get

$R_A^r = 0.947566$ and for the poor country we get $R_A^p = 1.104458$. I explained earlier that for a given investment level, the rich country will have a higher interest rate, but here we have two different investment levels. Given that the rate of return on investment is initially increasing then decreasing, we could set the income levels and population parameters so that either the Rich or the Poor country has a higher risk-free interest rate in autarky.

Now we can find the equilibrium interest rates under free international capital flows. In equilibrium, we must have $R^r = R^p$. Since we know the total world investment per entrepreneur is now $I_A^r + I_A^p = I^W = 1.551724$, we can find the equilibrium interest rates by setting $\dfrac{\pi'(I^r)Z}{1+\dfrac{\pi'(I^r)(I^r - y_1^r)}{\pi(I^r)}} = \dfrac{\pi'(I^W - I^r)Z}{1+\dfrac{\pi'(I^W - I^r)(I^W - I^r - y_1^r)}{\pi(I^W - I^r)}}$.

Solving, I find that there are three possible equilibria, which is shown in Table 1. In each of these possible equilibria, the riskless interest rate lies either above or below the interval between the autarky rates 0.947566 and 1.104458. Note that the efficient point, where $I^r = I^p = .775866$, such as point **C** on Figure 3, is not an equilibrium because at that point $R^r = 1.55442$ and $R^p = 1.06662$, which means savings would have an incentive to flow to the Rich country.

In the first equilibrium, we see that it corresponds to a point like **B** on Figure 3. This seems to be the most intuitive equilibrium starting from an autarkic equilibrium. In this case, in autarky the interest rate for the Poor country is higher. Therefore, we would expect savings to flow to the Poor country from the Rich country with free capital mobility. Since the Poor country is experiencing increasing returns to scale in autarky, while the Rich country is experiencing decreasing returns, the flow of funds from the Rich to the Poor will increase the interest rate in both countries. In equilibrium, the interest rate can end up higher than the interest rates in autarky. The Poor country still does not obtain the efficient level of investment because of the moral hazard introduced in the model. The second and third possible equilibria correspond to points like **A** and **D** on Figure 4. They are equilibria in a sense that all the income is invested and the interest rates are equal across countries. The transition from the autarky equilibrium to those points, however, is not as intuitive.

**5. Conclusions**

The paper combined increasing returns to investment and moral hazard into an international lending and borrowing model. The paper gives us an alternative explanation regarding the phenomenon of inefficient investment in poorer countries. I expanded on the model introduced by Gertler and Rogoff (1990), where they showed how asymmetric information can lead to less investment in the poorer country. By introducing initial increasing returns, however, we see that we can have equilibrium investment levels much lower in the small-country model than with diminishing returns. In the two-country model, I demonstrated that increasing returns helps explain how we can get savings flows from the Poor to the Rich country, and the possibility of multiple equilibria. I also demonstrated that equilibrium interest rates can lie outside of autarkic levels after the capital account is liberalized.

The literature gives several reasons why we don't see capital flowing from the richer countries to the poorer countries. These include technology levels, human capital levels (Lucas 1990), institutions (Alfaro, Kalemli-Ozcan, and Volosovych 2005), and serial default (Reinhart and Rogoff 2004). In this paper, as in Gertler and Rogoff (1990), I assumed the same technology and enforceable contracts in the two-country model. The only difference between the countries in our two-country model was their income.

The implications of the results in the small country case is that a country may need at least some minimum amount of funds to take advantage of the increasing returns, but still too much funds can lead to a moral hazard problem. Initial increasing returns with free capital flows would not be a problem in this model if it were not for the asymmetric information. To prevent default (or capital flight in this model), a lender may need to both lend more to take advantage of increasing returns and setup a better mechanism to monitor the investment. Previous models ignore the minimum lending requirement.

Further research can focus on different sectors of the economy to determine the impact of increasing returns on sovereign debt. Some sectors may have large economies of scale while other sectors may not. With asymmetric information, poorer countries may struggle to get loans for sectors that have large economies of scale, and they may have to settle for investment in less productive sectors. A sovereign debt model may be extended to analyze this situation.

**6. Appendix**

Proposition: With diminishing returns to investment, in response to capital account liberalization, savings will flow from the Rich to the Poor country; reverse flows cannot take place.

Proof : To prove this, I need to show that richer economies have lower interest rates in autarky under diminishing returns than poor economies. In autarky, investment per entrepreneur is equal to the total income of the country per entrepreneur, $I = \frac{y_1}{1-s}$.

The equilibrium interest rate in autarky is the rate which satisfies both the incentive constraint of the borrowers and the zero-profit condition of the lenders, where $P(Z) = Z - \frac{R}{\pi'(I)} = \frac{R(I - Y_1)}{\pi(I)}$. Solving for $R$ and substituting for investment, we have

$$R = Z\left(\frac{sy_1}{(1-s)\pi\left(\frac{y_1}{(1-s)}\right)} + \frac{1}{\pi'\left(\frac{y_1}{(1-s)}\right)}\right)^{-1}$$

, which is the same as equation (11). Taking the derivative with respect to the endowment income we have

$$\frac{\partial R}{\partial y_1} = -Z\left(\frac{\frac{s(1-s)\pi(I) - sy_1\pi'(I)}{[(1-s)\pi(I)]^2} - \frac{\pi''(I)}{(1-s)\pi'(I)^2}}{\left(\frac{sI}{\pi(I)} + \frac{1}{\pi'(I)}\right)^2}\right),$$

which is negative if $s(1-s)\pi(I)-sy_1\pi'(I)>0$. Dividing by $s(1-s)$, the inequality can be written as $\pi(I)>\pi'(I)I$, which is will always be true under diminishing returns. This completes the proof.

Under increasing returns, one can easily use the same proof to show that it is possible to have $\frac{\partial R}{\partial y_1}>0$. Since the autarkic interest rate in the Rich country may be higher than that of the Poor country, capital, therefore, can flow from the Poor to the Rich as we go from autarky to free international capital flows.

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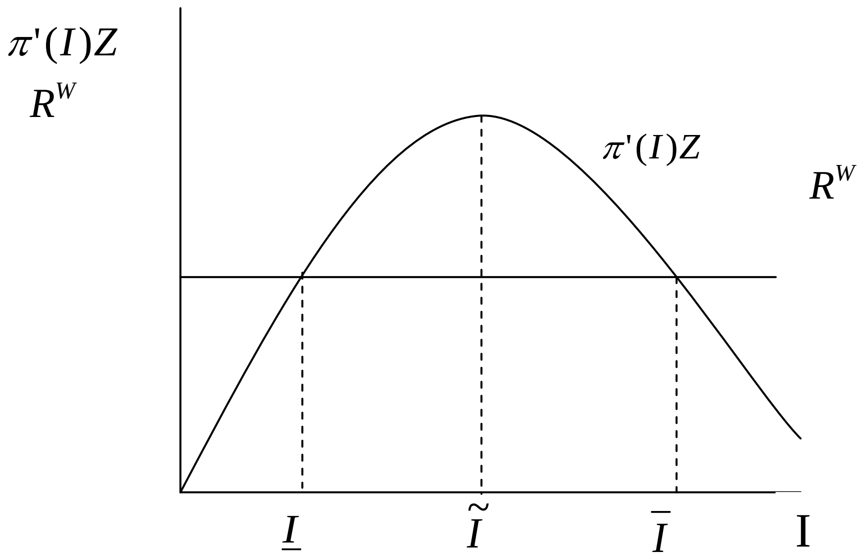
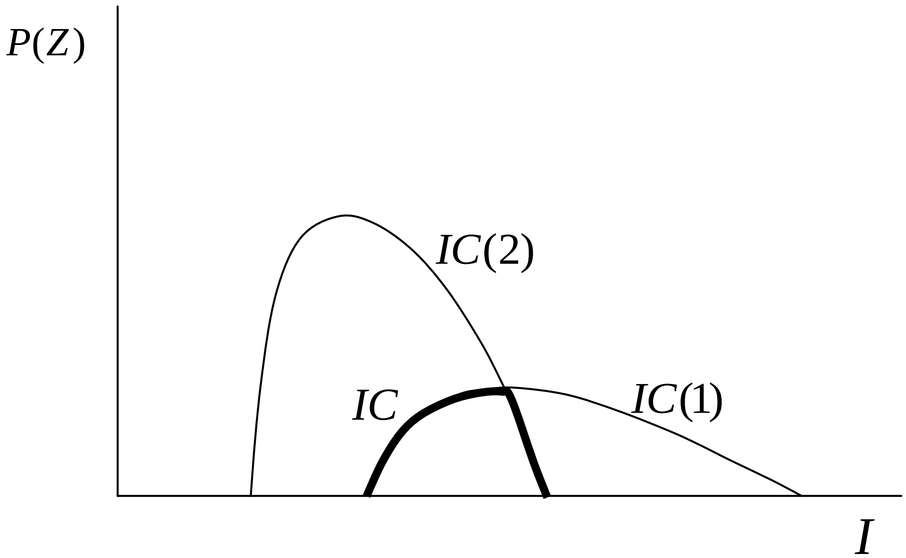
**Figure 1:** Marginal returns to investment



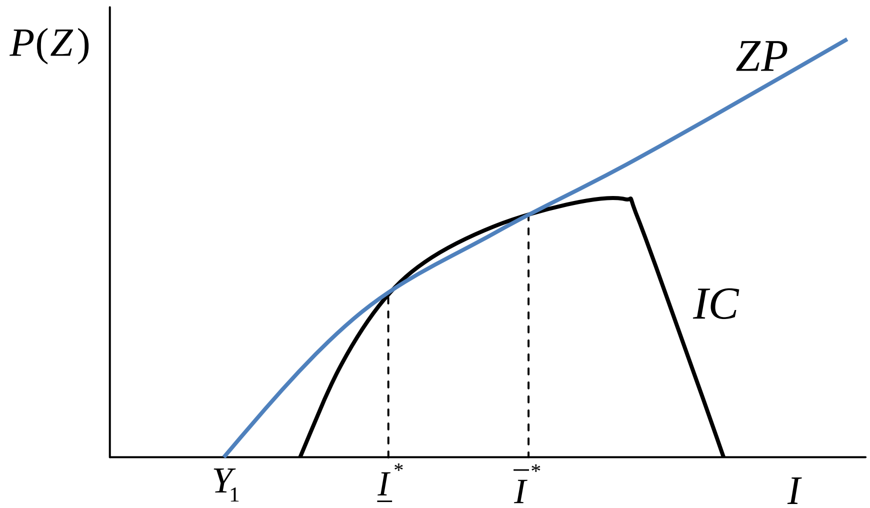

*Notes:* Figure 1 shows the marginal return to investment in the domestic economy, $\pi'(I)Z$, and the world interest rate. At low levels of investment, the marginal return in the domestic economy is low, but it increases and surpasses the world interest rate at higher levels of investment.

**Figure 2:** Incentive Constraint of the Borrower



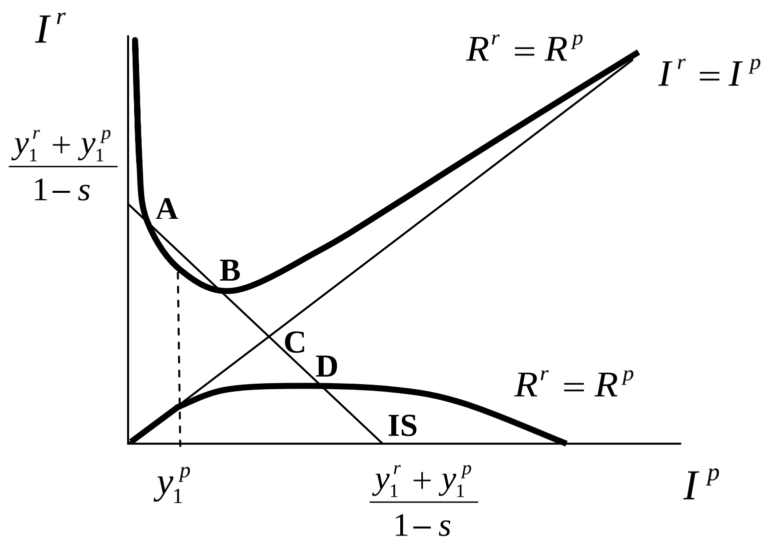

*Notes*: Figure 2 shows the incentive constraint of the borrower (IC), given that it must make a net marginal return equal to the riskless interest rate, IC(2), and it must at least get an overall return from domestic investment that is as high as the return from using all the funds to buy riskless securities, IC(1). For any required repayment, P(Z), which exceeds the points on the incentive constraint, the borrower will have an incentive to use all of its funds to buy riskless securities, and default on the loan.

**Figure 3:** Incentive-compatible Contracts



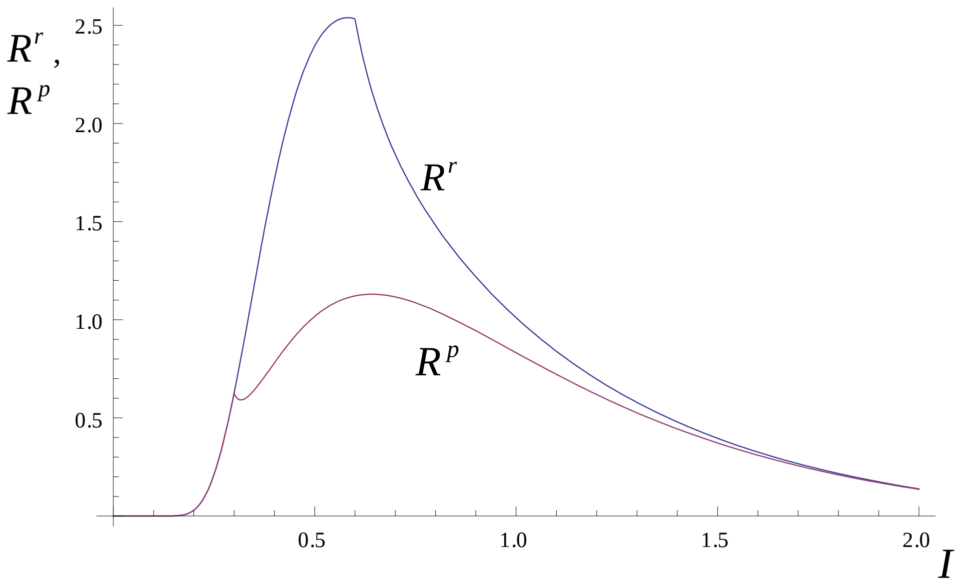

*Notes:* Figure 3 displays the possible contracts given that the lenders make zero profit (ZP), and the borrower will get an expected net return of at least the world interest rate. In this example, the borrower and lenders can agree on a repayment, P(Z), for investment levels between $\underline{I}^*$ and $\overline{I}^*$ .

**Figure 4:** Two-Country Equilibria




*Notes:* In Figure 4, three possible equilibria are shown. Two curves represent where the interest rates are equalized across nations ( $R^r = R^p$), and the IS curve is where all savings is invested. Equilibrium will exist where all the funds are invested and the interest rates are equalized, such as at points A, B, and D. Point C is the efficient point, but at the efficient point the rich country has a higher interest rate than the poor country because of the moral hazard problem.

**Figure 5:** Autarkic Interest Rates




*Notes:* Figure 5 shows the autarkic interest rates for the poor and the rich country at each given investment level.

Table 1: Possible Equilibria*

| Investment | | |
|---|---|---|
| Rich | Poor | World Interest Rate |
| 0.942276 | 0.609448 | 1.12488 |
| 1.1635 | 0.388224 | 0.746147 |
| 0.293773 | 1.257951 | 0.563546 |

* Rich income= 0.6, Poor income= 0.3

*Notes:* Table 1 shows three possible equilibria for a given income level of two countries. These are where all the funds are invested and the interest rates are equalized across countries.