The Composition of International Capital Flows: Risk Sharing Through Foreign Direct Investment

Rui Albuquerque*
University of Rochester

October 17, 2001

Abstract

Evidence on international capital flows suggests that foreign direct investment (FDI) is less volatile than other financial flows. To explain this finding, we model international capital flows under the assumptions of imperfect enforcement of contracts and inalienability of FDI. Imperfect enforcement of contracts leads to endogenous financing constraints and the pricing of default risk. Inalienability implies that it is not as advantageous to expropriate FDI relative to other flows. These features combine to give a risk sharing advantage of FDI over other capital flows. This risk sharing advantage translates into a lower default premium on FDI and a smaller response to changes in a country's financing constraint. The model produces the new implication that financially constrained countries borrow relatively more through FDI. Using several creditworthiness and country risk ratings to measure financial constraints we present supporting evidence of the model.

JEL Classification Numbers: F21, F34, F36.
Keywords: Foreign direct investment, intangible assets, volatility, risk sharing, imperfect enforcement, financing constraints, country risk.

---

*I would like to thank Greg Bauer, V. V. Chari, Hal Cole, Michelle Connolly, Lee Ohanian, Sérgio Rebelo, Roberto Rigobon, Martin Schneider, Ivan Werner and seminar participants at Carnegie Mellon University, Duke University, the International Monetary Fund, Northwestern University, the University of Rochester, the Wharton School, the 2000 Conference of the Society of Economic Dynamics in San José, the 2001 SIEPR Conference at Stanford University, and the IV LACEA/UTDT workshop in International Economics in Buenos Aires for comments. Please address all correspondence to: Simon School of Business, Carol Simon Hall, Rochester, NY 14627. E-mail: albuquerque@simon.rochester.edu. Phone: (716) 275-3956. Fax: (716) 461-3309. The usual disclaimer applies.

1 Introduction

International private capital flows represent a major source of financing of economic activity in developing countries. For these countries, it is often argued that a critical component of international financing is foreign direct investment (henceforth FDI).[1] The argument is based on two main reasons. First, foreign direct investment is less volatile than other forms of international capital flows. Second, the share of FDI is relatively higher for developing versus developed countries. As discussed below, existing theories of FDI have difficulty in accounting for these facts. This paper attempts to fill in this vacuum by arguing that FDI is a form of investment that is best suited to provide risk sharing in a world economy where contracts are plagued by imperfect enforcement mechanisms.

There is substantial evidence that FDI flows are less volatile than other forms of financial flows to developing countries. Some of this evidence comes from crisis episodes. The World Bank's (1999a) "Global Financial Development" reports that during the Latin America debt crisis of the 1980's FDI flows to these countries collapsed, but the fall in other long-term (and short-term) flows from banks and the bond market was 7 times greater. A parallel story occurred during the Mexican debt crisis in 1994. FDI inflows fell from US \$11 billion in 1994 to US \$8 billion in 1996, a drop of 27%, and recovered fully by 1997. However, portfolio equity and debt flows fell by 89% and 45% respectively in just one year, from 1994 to 1995. The recent currency and banking crisis in East Asia has seen a drop of 22% in net-long term inflows to these countries, while FDI has been extremely resilient falling by less than 5% from 1997 to 1998.[2]

Evidence of differential volatility is also abundant outside crisis periods. Figure 1 plots the histogram of the (absolute value of the) ratio of the coefficient of variation of net private FDI inflows versus that of net private non-FDI inflows. Both flows are normalized

[1] Investment through FDI alone represents a large portion of overall domestic investment. For example, in the 10 major recipient countries of FDI during the 1990-97 period–all developing countries–FDI accounted for an average of roughly 20% of total private investment. For the overall sample of developing countries it accounted for 8.7% of gross fixed capital formation in 1996 (see World Bank 1999a). Furthermore, FDI outflows from developing countries were roughly non-existent over the 1990-97 period. The evidence is quite different for developed countries. While these countries have the largest inflows and outflows of FDI, the net flow is typically small.

[2] The countries considered are Indonesia, Korea, Malaysia, the Philippines, and Thailand. The data on net inflows to these countries includes FDI and official flows, so 22% is presumably a lower bound on the reduction of private capital inflows.

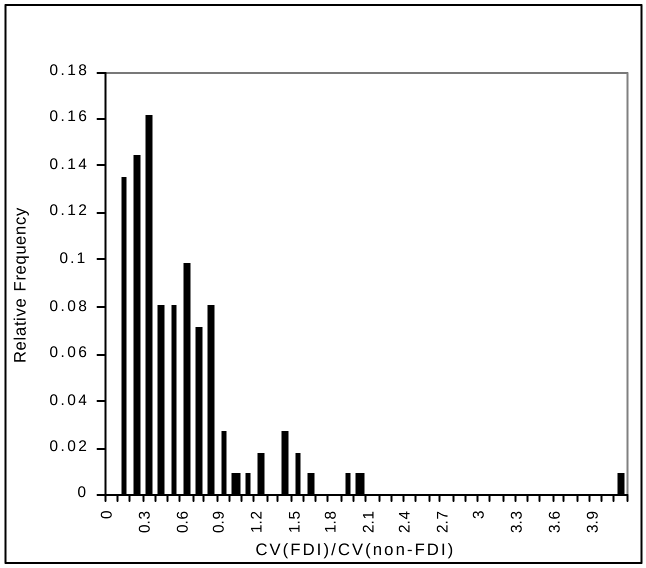

Figure 1: Relative volatility of FDI versus non-FDI flows.

by gross private capital flows (normalizing by GDP-PPP adjusted gives similar results). The data is from the World Bank (1999b) "World Development Indicators" and covers 111 countries from 1975 to 1997.[3] According to figure 1, 88% of the countries in the sample have lower coefficient of variation of FDI than that of other inflows. The median (average) coefficient of variation is 0.79 (1.4) for FDI and 2.35 (14.16) for non-FDI flows.[4]

This difference in volatilities is also present when we restrict attention to long term flows. Lipsey (1999) computes the coefficient of variation of several capital flows from 1969-1993. He reports significant differences in volatility between FDI and other net long term flows for developing countries and to a lesser extent to developed countries: the ratio of FDI's volatility to that of long term non-FDI flows is about 0.59 for Latin America, 0.74 for South East Asia, 0.86 for Europe, and 0.88 for the US.

Our point of departure is this: a typical characteristic of FDI into developing countries is that recipient countries are generally unable to operate (at least as efficiently,

[3] For most countries the time span is shorter.

[4] UNCTAD (1998), World Bank (1999a), and Lipsey (1999, 2001) also report that FDI is unconditionally less volatile than other flows. Also related are the studies by Chuhan, Perez-Quiros and Popper (1996) who observe that FDI responds less to shocks, and Sarno and Taylor (1999) that show that FDI is mostly composed of a permanent component. Claessens, Dooley and Warner (1995) is the only study we know of that fails to confirm this finding. However, they use a much smaller sample of 5 developed and 5 developing countries.

if at all) these investments without the intangible assets of the multinational company. Examples of these intangible assets include human and organization capital, and technological advances. Because these assets are inalienable to a large extent, their residual value to the recipient country is relatively small. For example, multinationals typically rely on blueprints to secure their investments. This is true in high technology industries such as pharmaceuticals, but also in low technology ones such as the soft drink industry.[5] However, most other investments including bank loans and bond financing are fully appropriable. For our analysis, inalienability is the main difference between direct investment and other international inflows of capital.

Our modeling strategy builds on Eaton and Gersovitz (1984) who present a model of foreign direct investment under the risk of expropriation. They argue that the level of intangible assets is an important determinant of heterogeneity in international capital flows. They show that it may be optimal for investors to overinvest in technologies with more intangible assets in order to reduce the risk of expropriation. We extend their analysis by also modeling foreign *indirect* investments, where the absence of intangible assets increases the incentives to expropriate.

The existence of intangible assets in many production/managerial activities together with market imperfections that prevent the correct pricing of these assets have been used to justify transnational corporations, i.e. intra-firm as opposed to arm's length relationships (e.g. Caves (1982)). The empirical evidence recently surveyed by Caves (1996) broadly suggests that this is an important force driving FDI. For example, research and development and advertising expenditures–typically associated with the presence of intangible assets–are larger in industries in which there is a stronger presence of transnational corporations.

[5] Clearly, though, by investing abroad multinationals increase the likelihood of dissipating the value of their intangible assets. This occurs because host countries of FDI can hire specialized work force from abroad, or train their own work force. However, these possibilities are financially costly and typically involve a large time lag from expropriation to using the capital in place. Reverse engineering is one of the most popular ways to imitate a technology. Mansfield et al. (1981) report the estimated imitation cost and time for 48 new products in the Chemicals, Drugs, Electronics, and machinery industries. These estimates are based on surveys to some of the largest US firms in these 4 industries. For innovations costing over $1 million, an average of 23% of the products cost more to imitate than they did to innovate and an average of 17% of the products took more time to imitate than they did to innovate. These authors also report that most products cost at least 50% in time and dollars to replicate. It is our belief that these imitation costs are likely to be much higher for firms in developing and low income countries. In a different survey, Mansfield and Romeo (1980) report that 10 out of 26 technologies became known to some non-US competitor after at least 4.5 years.

Our second main assumption is that international financing contracts lack the proper mechanisms to enforce repayment. In Section 2, we build a model of the composition of international capital flows to developing countries based on these two main premises: (i) that FDI is inalienable due to intangible assets, and (ii) that sovereign capital flows lack international enforcement mechanisms.

Section 3 analyses the predictions of the model for the optimal composition of international capital flows. First, because of expropriation risk, capital flows into financially constrained countries command a default premium. Second, because FDI is inalienable, the default premium associated with FDI inflows is lower than that of non-FDI inflows. In the model, when capital shares are identical, this implies that financially constrained countries get a relatively larger proportion of FDI. Moreover, a higher default premium to non-FDI flows means that changes in a country's borrowing constraint affect non-FDI flows to a greater extent. We derive our main result on the relative volatility of capital flows analytically when aggregate shocks are iid. We use numerical simulations of the model to investigate how the persistence of aggregate shocks affects the average volatility of FDI versus other capital flows.

In Section 4 we investigate the model's new prediction that financially constrained countries have relatively larger inflows of FDI capital. We identify financial constraints with low sovereign credit ratings, or, more broadly, with low overall country risk ratings. This assumption relies on credit ratings being good indicators of a country's ability to borrow. Our results show that there is a negative association between the FDI share of gross private flows and a country's credit rating. Moreover, the association between FDI share and credit rating is robust to conditioning on other variables. The variation in credit rating accounts for a significant portion of the total variation in FDI inflows. This evidence is broadly supportive of the model.

The combined empirical findings we discuss are hard to understand with other explanations for FDI.[6] First, theories based on competitive advantages (e.g. lower input costs, supply of skilled/unskilled workers, market proximity) or taxation do not seem able to explain the systematic cross sectional evidence that FDI flows are less volatile than other investment flows, though they are certainly useful in accounting for the level of FDI (see Razin, Sadka, and Yuen (1998) for a discussion of taxes and capital flows). Second,

[6] Nonetheless, all these are extremely useful tools to understand such things as the composition of FDI flows, the country of destiny, etc.

FDI flows to developing countries are mostly in the form of Greenfield investments as opposed to mergers and acquisitions.[7] Hence, it does not seem a good starting point to explain FDI flows to developing countries by appealing to high domestic corporate costs of external financing (see Froot and Stein (1991)).[8]

Finally, our theory does not make use of investment irreversibilities or inertia type arguments as in Albuquerque and Rebelo (2000). Though these are likely candidates to explain the lower volatility of FDI, they would have a hard time in explaining the connection between a country's credit worthiness and FDI flows. Two important remarks about FDI being irreversible are in order. In practice, FDI can be easily reversed. For example, the subsidiary can borrow against its collateral domestically, and lend the money back to the parent company. As another example, note that a considerable portion of FDI is intercompany debt, which the parent company may recall at short notice. (Both strategies would result in a drop in measured FDI.) The second remark is that in bad times all financial products are illiquid and thus costlier to move around. Thus, the role of irreversibility becomes an empirical question.

Our model relates to the theory of debt in Hart and Moore (1994) and Albuquerque and Hopenhayn (2001). There, the borrower possesses the human capital and the lender is unable to operate the technology by himself. With FDI, the difference is that the foreign investor is both the lender of the capital and the owner of the technology. But, because investments are physically located in the recipient country, these properties of FDI imply that neither party to the contract is able to extract value from the investment upon default by the borrower.[9] Our model is borrowed from Thomas and Worrall (1994). They analyze the investment dynamics of multinational companies. We introduce heterogeneous capital flows into their model and relax some of the assumptions. The model presumes that international lenders and borrowers lack commitment mechanisms to long term contracts. The main difference with Albuquerque and Hopenhayn (2001) is that in the later full commitment is assumed on the lender's side.

The question we ask is complementary to Lucas' (1990) question of why doesn't

[7] Greenfield investments (e.g. setting up a subsidiary from scratch) account for roughly 87% of the FDI into developing countries in 1997, and 94% in 1991 (see UNCTAD (1998)).

[8] It could be argued that more favorable asset prices resulting from large exchange rate depreciations, like those in East Asia in 1997, would favor FDI. But, then, how do we rationalize the large decrease in portfolio equity flows in East Asian countries?

[9] The paper has obvious links to the general literature on sovereign debt under imperfect commitment on the borrower's side (see Eaton and Fernández (1995) for a review).

capital flow from rich to poor countries. Our focus is on what capital does flow from rich to poor countries. Lucas reasoned that the lack of international enforcement mechanisms could not explain the *level* of capital flows.[10] This paper tries to provide some insights into Lucas' question arguing that a particular *composition* of capital flows is likely to emerge in a world of imperfect commitment.

Section 5 concludes the paper with a brief discussion of the normative implications of our results. Appendices A and B contain the proofs of the propositions and Appendix C describes the numerical solution method used in the paper.

2 The Model

We think of our model as one of lending to developing countries.[11] First, for these economies there is a stronger belief that legal enforcement of international contracts is subject to political willingness and uncertainty, and hence is more fragile. Second, we think that capital flows among developed countries are very different in nature.[12] In line with this interpretation, we model the supply of international capital by assuming that international investors are risk neutral and unconstrained.

The basic framework is from Thomas and Worrall (1994). We enrich their model by studying the implications of heterogeneous capital flows and relaxing some of their assumptions. In the model we shall impose considerable symmetry between the different capital flows. Besides tractability, the main purpose is to (theoretically) isolate the effect of the inalienability of FDI.

The economy consists of an international investor and the domestic country's representative consumer. The domestic consumer is risk averse while the international investor is risk neutral. There are three investment opportunities available to the international investor. One is the international bond market which offers a constant interest rate r. The

[10] His argument was that political (country) risk is a recent phenomena, and that it cannot explain why wouldn't capital flow from rich to poor countries in the colonial times where there was legal enforcement of contracts. In spite of this, we contend that in the last decades large sovereign debt default and renegotiation deals associated with capital expropriations have made investors wary of the lack of international enforcement of contracts.

[11] However, our choice of interpretation should not constrain the reader's.

[12] An example of this differential behavior is the much higher percentage of Mergers and Acquisitions that accounts for FDI between developed countries. Mergers and Acquisitions in total FDI for developing countries was only 12.4% in 1997, up from 5.4% in 1991. In contrast, the worldwide share of Mergers and Acquisitions in FDI inflows averaged 50% during 1985-97 (UNCTAD (1998)).

international investor can also invest in two projects located in the host country. One project is inalienable by the domestic consumer while the other is fully appropriable. We interpret flows into the inalienable project as FDI and flows into the appropriable project as non-FDI.[13,14] We do not explicitly model the location/entry decision of multinational companies. This is an extremely useful abstraction that allows us to focus on the dynamics of the financial capacity of the host country.

In our setup long term contracts between investors and borrowers are written contingent on any possible history of events. As Spear and Srivastava (1987) and Green (1987) originally showed, there exists a recursive representation to these contracts. To conserve on notation and space we make use of these results to write the problem directly in a recursive fashion. We shall make brief use of the sequence representation of these contracts in the next section.

There is only one aggregate shock s. The aggregate shock s follows the continuous autoregressive process with correlation ρ, and unconditional mean $\bar{s}$,

$$\ln s' = \rho \ln s + (1-\rho) \ln \bar{s} + \varepsilon', \text{ and } \varepsilon' \sim N\left(0, \sigma_{\varepsilon}^2\right). \tag{1}$$

The choice of a single aggregate shock is motivated by our desire to remove any asymmetries between the investment choices besides those originating from the inalienability of FDI. It is easiest to think of the aggregate shock as being total factor productivity shocks, but we may also think of shocks to the country's banking system, or to the exchange rate system. The initial shock s_0 is drawn from a distribution $F(s)$.

At the beginning of the period the long term contract assigns an utility level V to the developing country. This life-time utility level is obtained through a period utility of

[13] The IMF definition of FDI comprehends all investment with lasting *corporate control interests* on firms residing in other countries, typically with equity shares of 10% or more (see Lipsey (1999) for a summary and history of several definitions). Also, it is clear from discussions on measurement issues that the goal in the breakdown between FDI and Foreign Portfolio Investment is to capture under FDI those flows which normally include the transfer of intangible assets (see for example UNCTAD 1999). Therefore, the focus of these two approaches is on measuring the same flows (see also Caves (1982,1996) and Eaton and Gersovitz (1984)).

[14] The definition of FDI across countries normally includes retained earnings, equity capital and intercompany debt transactions. An investment with an equity share of less than 10% may be counted as FDI if a management position is implied. Balance of payments data do not include capital raised in host countries as FDI. Also they omit cross-border flows of goods and services. Foreign Portfolio Investment includes equity securities, debt securities, money market instruments and financial derivatives; mostly traded or tradeable securities in organized and other financial markets. Finally, Other Investments include trade credit, loans, financial leases, currency deposits–mostly short term assets. For more details see UNCTAD (1999).

$u(c) = \ln(c)$ and a continuation value $V(s')$. Thus, the promise keeping constraint:

$$V = E\left[\ln(c) + \frac{1}{1+r}V(s')\,|s\right], \tag{2}$$

where $E(.|s)$ is the conditional expectations operator.

The contract specifies the split of the current output level between domestic consumption (c), investment $(k_f + k_o)$, and the trade balance (τ) or net-exports. The output results from two investment projects in which international investors participate. These projects may differ in their capital share, α_f, $\alpha_o < 1$. This gives the aggregate resource constraint:

$$c + k_f + k_o + \tau = s'Ak_f^{\alpha_f} + s'k_o^{\alpha_o}, \tag{3}$$

where k_f is the level of FDI or inalienable capital input, k_o is the level of appropriable capital input, and A is a relative scaling factor. This model embeds the role of taxes and tax advantages of FDI $(A > 1)$. As will become clear later on, in our framework, the scale factor can explain FDI levels, but not the relative volatility of FDI in the absence of inalienability. We abstract from other factors of production by assuming they are fixed factors. This of course ignores any crowding out or crowding in that might ensue, but is irrelevant if the impact on the domestic factor markets of these heterogenous forms of capital is symmetric.

For simplicity we assume full depreciation on both capital stocks. Besides the different capital shares, the only other distinction we make between FDI and other capital flows is on the way each of the inputs affects the developing country's utility level under autarky, $U(k_f, k_o, s')$. (More on this below.)

The host country's representative consumer cannot commit to a long term contract. The international investor has commitment, but of a limited nature in that a participation constraint must be satisfied. As in Thomas and Worral (1994) we define a *self-enforcing contract* by requiring that capital flows obey two participation constraints.[15] For both agents the participation constraint says that the utility under the contract is at least as large as the utility outside the contract. That is, for the domestic consumer:

$$\ln(c) + \frac{1}{1+r}V(s') \geq U(k_f, k_o, s'), \tag{4}$$

[15] We make this assumption because it looks more in line with real life scenarios. However, giving full commitment to the international investor does not change the qualitative nature of our main result.

for each $s' \in S$. Constraint (4) is a necessary condition to generate endogenous barriers to international capital flows by limiting the size of k_o and k_f. The international investor's participation constraint limits the long term losses at any time. Denoting her utility function in state (V, s') by $B(V, s')$, this restriction dictates that $B(V, s') \geq 0$.

Before continuing, we describe the timing of the model in a more organized fashion. Figure 2 presents a visual description of the main events during each period. At the beginning of each period, and before the shock s' is realized, the investment of k_o, and k_f is made, and consumption is decided. Afterwards, the aggregate shock is observed and output is generated. At this stage the consumer may choose to default on the contract. If default does not occur, output is allocated into consumption and the trade balance as previously determined.

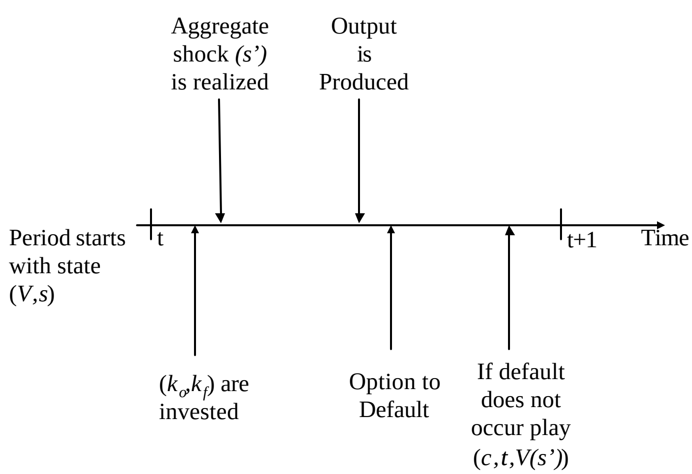

Figure 2: Sequence of events within a period.

The international investor's utility is just the expected discounted net flows from the borrowing country:

$$B(V, s) = \max_{c, k_f, k_o, \tau, V(s') \geq \underline{V}} E\left[\tau + \frac{1}{1+r} B(V(s'), s') \,|s\right] \tag{5}$$

subject to (2)-(4) and to $B(V(s'), s') \geq 0$ for all s'. The constraint that $V(s') \geq \underline{V}$, with $\underline{V} > -\infty$, is introduced because the period utility of the domestic consumer is unbounded. This restricts the amount of punishment that may be given to a country.[16]

Note that the problem of maximizing (5) subject to (2)-(4) is very similar to the usual small open economy problem in International Macroeconomics. Except for the non-default constraint (4), the main difference is that instead of maximizing the consumer's lifetime utility subject to resource and balance of payments constraints, we solve for the dual problem in which the investor's lifetime utility is maximized subject to a resource constraint and the agents' utility (2). We show below that the solution to (5) lies in the Pareto frontier and so the two problems coincide.

In solving for the borrower's autarky problem we assume: (i) that default occurs on both capital flows simultaneously,[17] (ii) that without the human capital from the international investor the FDI technology cannot be operated any longer once the country defaults, and (iii) that only a share of the current revenues $\theta \in [0, 1]$ can actually be transformed into investment towards the appropriable activity. Thus, $1 - \theta$ is the degree of inalienability of FDI. Even though we model (ii) and (iii) as exogenous, they can be motivated as a rational response of multinational firms to country risk (Eaton and Gersovitz 1984). Under these assumptions, we show in appendix A that the value of the host country's representative consumer under autarky is given by:

$$U(k_f, k_o, s) = d_0 + d_1 \ln\left(\theta A k_f^{\alpha_f} + k_o^{\alpha_o}\right) + \Lambda(s), \tag{6}$$

where d_0 and d_1 are positive constants and $\Lambda(s)$ is a continuous function of s. This definition of the domestic investor's life-time utility in the autarky regime accommodates two alternative specifications on the efficiency of investment. In one, investment is contemporaneous with production under autarky. In the other, investment lags one period as in the Neoclassical Growth Model. These different assumptions are not relevant for our qualitative results. In deriving the constants d_0 and d_1 and the function $\Lambda(s)$, we make extensive use of the assumptions of log-utility and full depreciation.

What is the role of our assumptions on the FDI activity? It is important that some output from the FDI activity be lost if the country defaults. This results in a lower incentive to default and hence in a lower risk premium on FDI. It is not as important

[16] One way to endogeneize the constant $\underline{V}$ is to explicitly introduce competition among international investors at any time during the contract as in Phelan (1995).

[17] If we were to allow separate default we would in fact be favoring the risk sharing role of FDI. Again, this symmetry is intended to isolate the effect of the inalienability on the volatility of both flows.

that we require all output from the FDI activity to be consumed instead of transformed to investment, although this makes the results stronger. Finally, we want to emphasize that θ does not act like a tax, though it could be interpreted as a state-contingent tax: FDI flows are not subject to it if the country does not default (see (3)).

Equilibrium Contracts

At the start of the contract the international investor makes a take-it-or-leave-it offer of contingent sequences of $\{k_{ot}, k_{ft}, \tau_t, c_t\}_{t=0}^{\infty}$ to the domestic consumer. An equilibrium contract gives just enough expected revenues to the international investor that compensates her for any initial fixed costs I, hence $V_0 = \sup\left\{V : \int B(V, s') F(ds') \geq I\right\}$. These fixed costs may be related to setting up a factory or promoting a brand name.

Having formulated our problem we now turn to a characterization of the solution.

3 The Optimal Composition of Capital Flows

The self-enforcing nature of the contract, in particular the constraint $B \geq 0$, makes it infeasible to use standard dynamic programming arguments to show the existence and uniqueness of a value function B. However, we can show an important property of the function B. Let $h_t = \{s_l, k_{ol}, k_{fl}, \tau_l, c_l\}_{l=0}^{t}$ be an history of events up to time t. Consider the set $\Gamma(h_t)$ of all contract *feasible* sequences $\gamma(h_t) = \{k_{ol}, k_{fl}, \tau_l, c_l\}_{l=t}^{\infty}$. Define recursively the domestic consumer's utility $V(\gamma; h_t) = E\left[\ln c(h_t) + \frac{1}{1+r} V(\gamma; h_{t+1})\right]$ from following the recommendations of contract γ after history h_t. Any contract in Γ satisfies the self-enforcing constraints, the resource constraint (3), and $V(\gamma; h_{t+1}) \geq \underline{V}$ from time $t \geq 0$ onwards. The Pareto frontier at time t that yields at least utility V_t to the domestic consumer is defined by the mapping:

$$B^P(V_t, s_t) = \sup_{\gamma \in \Gamma(h_t)} \left\{ E\left(\tau(h_{t+1}) + \frac{1}{1+r} B(\gamma, h_{t+1})\right) | V(\gamma; h_t) \geq V_t \right\}$$

where $B(\gamma, h_t)$ is defined recursively by $B(\gamma, h_t) = E[\tau(h_{t+1}) + \frac{1}{1+r} B(\gamma, h_{t+1})]$. Finally, define B^F to be the Pareto frontier that results once we ignore the self-enforcing constraints. That is B^F characterizes the Pareto frontier when full commitment is possible by both agents.

Our first result says that the Pareto frontier can be computed using our recursive approach outlined in the previous section. Let T be the operator described in (5), that is

$$T(f)(V,s) = \max_{c,k_f,k_o,\tau,V(s')\geq \underline{V}} E\left[\tau + \frac{1}{1+r} f\left(V\left(s'\right),s'\right)|s\right]$$

where the maximization is subject to (2)-(4) and $f\left(V\left(s'\right),s'\right) \geq 0$ for all s'. Construct the sequence of functions $f^{(0)} = B^F$, $f^{(n)} = T\left(f^{(n-1)}\right)$, for $n > 1$, by iterating on the operator T.

Lemma 1 *(Thomas and Worrall 1994, Lemma 1) $f^{(n)}$ converges to B^P pointwise.*

Thus, we can take $B(V,s) = B^P(V,s)$. An immediate consequence of this lemma is that the optimal contract will give allocations that lie in the downward slopping portion of the Pareto frontier. Together with the fact that in equilibrium the domestic consumer is extracting the maximal surplus from the investor, these allocations are the best possible ones the domestic consumer would have chosen if he were to choose a contract γ himself for any given value of B.

Assume that B is concave in V for each s. This will be confirmed in all our simulations below. Suppose the current state is (V,s). Let π' be the conditional density of the aggregate shock. Attach the Lagrange multipliers λ, $\pi'\psi(s')$, $\pi'\delta(s')$, and $\pi'\phi(s')$, respectively to constraints (2), (4), $B\left(V\left(s'\right),s'\right) \geq 0$, and $V\left(s'\right) \geq \underline{V}$ for each shock s'. Eliminating the variable τ, the first order conditions for the investor's problem are:

$$c = \lambda + E\left[\psi\left(s'\right)|s\right]$$

$$E\left(s'|s\right) A\alpha_f k_f^{\alpha_f - 1} = 1 + E\left[\psi\left(s'\right) U_{k_f}\left(k_f, k_o, s'\right)|s\right] \tag{7}$$

$$E\left(s'|s\right) \alpha_o k_o^{\alpha_o - 1} = 1 + E\left[\psi\left(s'\right) U_{k_o}\left(k_f, k_o, s'\right)|s\right] \tag{8}$$

$$\left(\frac{1}{1+r} + \delta\left(s'\right)\right) B_V\left(V\left(s'\right),s'\right) + \frac{1}{1+r}\left[\lambda + \psi\left(s'\right)\right] + \phi\left(s'\right) = 0, \text{ for all } s',$$

together with the constraints (2), (4), and $B\left(V\left(s'\right),s'\right) \geq 0$ and $V\left(s'\right) \geq \underline{V}$ for each shock s'. The envelope condition is: $B_V(V,s) = -\lambda$. Let the solution to this system of equations be the functions $\left\{k_o^*, k_f^*, \tau^*, c^*, V\left(s'\right)\right\}$ with associated lagrange multipliers.

The first condition together with the envelope condition just say that the slope of the Pareto frontier is given by $E\left[\psi\left(s'\right)|s\right] - c < 0$. Thus, the expected value of the shadow cost of the default constraints is bounded above by c. The second and third conditions dictate the optimal composition of capital flows. In each, the marginal expected product of capital is equated to its marginal cost, plus a default premium.[18] The *default premium* for capital k_x is defined as $E\left[\psi\left(s'\right)U_{k_x}\left(k_f,k_o,s'\right)|s\right]$; it measures the marginal cost of higher incentives to default brought about by a marginal unit of capital. Finally, the last condition describes the trade-off across different states of nature when choosing continuation utility levels.

We use the first order conditions (7) and (8) to define financing constraints in our model. A *financially constrained country* has positive default premium of either capital. This is a definition of financial constraints on the intensive margin.

We start with the analysis of capital flows when there is full commitment by both agents. This will give a benchmark for comparison and will help us understand the role of commitment in generating financial constraints.

3.1 The Perfect Enforcement Solution

To better understand the role of imperfect enforcement and the inalienability of FDI we start by analyzing the solution under perfect enforcement. Eliminating the self-enforcing constraints from the problem yields the following solution (i.e. set $\delta\left(s'\right)=\psi\left(s'\right)=0$):

Proposition 2 *Under perfect enforcement, the optimal choices* $\left(k_f^F,k_o^F\right)$ *solve:*

$$\alpha_f E\left(s'|s\right)Ak_f^{\alpha_f-1}=\alpha_o E\left(s'|s\right)k_o^{\alpha_o-1}=1,$$

for a country starting the current period with shock s*. There is no default premium. The coefficient of variation of* k_f *relative to that of* k_o *is* $\frac{1-\alpha_o}{1-\alpha_f}$.

Clearly, the self-enforcing constraints are at the heart of the financing friction. If there is perfect enforcement the default premium is zero and marginal revenues are equalized. The different sensitivity of capital flows can only arise because the capital shares differ among these investment opportunities. Inalienability plays no role. This allows us to isolate the effect of the inalienability of FDI once we introduce a borrowing constraint.

What is the role of taxes in explaining the relative volatility of FDI? Recall that $A>1$ has the interpretation of a subsidy to FDI. Subsidies are irrelevant to determine the relative sensitivity of FDI (though they are determinant in explaining the level of

[18] Because of the timing, capital becomes operational in the same period of purchase and so its marginal cost (absent any other friction) is 1 instead of $1+r$. This detail is not relevant for our qualitative results.

FDI). As we will see below this will also be the case for $\theta = 0$ (maximum inalienability of FDI).

3.2 The Imperfect Enforcement Solution

The first main prediction of the model concerns the default premium and level of FDI versus other flows.

Proposition 3 *The default premium is higher for non-FDI flows. When the elasticities $\alpha_f = \alpha_o$ and $A \geq 1$, then the level of FDI is no smaller than the level of appropriable capital, i.e., $k_f^* \geq k_o^*$. Furthermore, $k_f^* \leq k_f^F$ and $k_o^* \leq k_o^F$ with inequality holding strictly every time the country is constrained.*

With the financial frictions in place the default premium becomes positive. That the default premium is lower for FDI is just a reflection of its inalienability. When the capital shares are identical and $A \geq 1$, the concavity of the production functions then dictates that FDI be higher if the country is constrained. If a country is unconstrained then $k_f^* = k_f^F$, $k_o^* = k_o^F$. Thus, we obtain the corollary that the FDI share is higher for financially constrained countries.[19]

If $A < 1$ then concavity of production functions is not the only ingredient affecting the composition of capital flows. Hence, it is possible to have $k_f^* < k_o^*$ when A is small enough.

How does the relation between default premia and size translate into volatility? This question is in general very hard to answer, but when shocks are iid it turns out that there is a sharp result.

Proposition 4 *Let the aggregate shock be iid. The ratio of the coefficient of variation of FDI to that of non-FDI flows is smaller than $\frac{1-\alpha_o}{1-\alpha_f}$ if, and only if $\theta < 1$.*

This is the main result of the paper. If FDI is inalienable ($\theta < 1$), then FDI displays relatively less volatility than under perfect enforcement. For simplicity of exposition

[19] This result contrasts with Kraay et al. (2000) who also use the inalienability of FDI to discuss its relative size. Their result seems to depend upon the assumption that the probability of default does not change as more FDI and non-FDI capital flow into the country.

let input shares be identical (i.e., $\alpha_f = \alpha_o$). With equal input shares, and in spite of greater FDI inflows, the coefficient of variation of FDI is actually lower than that of non-FDI. Since under perfect enforcement there is no difference in volatilities, this difference must arise because of the financing constraint and of the inalienability of FDI ($\theta < 1$). Furthermore, the qualitative result is independent of the size of A.

The reason FDI is less volatile is because it carries a smaller default premium. The default premium is lower for FDI flows because these are less appropriable under default. A lower default premium means that FDI flows are closer to their unconstrained optimum. Thus, shocks that increase the borrowing capacity of the host country (by increasing future V) lead to larger adjustments of non-FDI flows (these are farther away from the optimum).

Only if the capital share of FDI is larger than that of non-FDI flows ($\alpha_f > \alpha_o$), could FDI become relatively more volatile. The reason is that, even if the optimal values k_f^* and k_o^* were equal, the relative convexities of the production functions might induce a stronger response of k_f. This makes it harder to analyze the volatility of capital flows. However, when shocks are iid and FDI is fully inalienable ($\theta = 0$), k_f is constant through time and equal to k_f^F. In this case, the relative volatility of FDI is trivially smaller than that of non-FDI flows independently of the capital shares. (And independently of A as well.) Hence, one would expect a significant role for the capital shares, but one that vanishes as the inalienability of FDI becomes maximal.

To conclude, while the role of the capital shares is to determine the relative convexity of the default premium in each activity, the inalienable component of FDI determines the willingness of financially constrained countries to use FDI instead of other capital flows.

This result allows us to rationalize, based on the risk sharing properties of FDI, the recent outflows of capital from the East Asian Tigers all of which suffered a negative aggregate shock that tightened (at least temporarily) their access to international credit markets.

3.3 Numerical Simulations

In this subsection we report the results of numerical simulations of the model. We analyze how relative volatilities change when shocks are persistent and FDI is more or less inalienable. Despite ignoring important features of production and investment (recall that there is full depreciation of capital and no domestic investment or labor supply), the model fares quite well in explaining the differential volatilities in FDI and non-FDI flows reported in the Introduction of the paper.

Table 2. Baseline Parameters.

Parameter	Value	Description
θ	.1	Appropriability parameter
r	.04	Real interest rate
α_f	.4	capital share of FDI activity
α_o	.4	capital share of non-FDI
A	1	Scale parameter of FDI activity
ρ	.95	Auto-correlation of the shock
$\bar{s}$	1	Unconditional mean of the shock
σ_ε	.007	Unconditional variance of the shock

Table 2 summarizes our initial parameter choices. The period considered is one year. The choice of all parameters except θ is borrowed from the real business cycle literature (see Cooley and Prescott 1995). The real interest rate is the standard value of 4%. The choice of 0.4 for the capital share coincides with estimates for the US economy. It is also consistent with estimates of the capital share for several developing countries in Barro and Sala-i-Martin (1995, Table 10.8). These estimates range from .29 to .69. In all our simulations we require that the results be unaffected by the capital shares.[20]

We vary the values of the inalienable parameter θ and the auto-correlation parameter ρ in our experiments.

To solve the model we discretize the state space. The aggregate shock takes on one of 5 possible values. The transition matrix $[\pi_{ij}]$, with $\pi_{ij} = \Pr[s' = s_j | s = s_i]$, is chosen to be a discrete state space representation of the autoregressive process (1). This is done with the numerical quadrature method developed by Tauchen and Hussey (1991). To calibrate the distribution of the initial shock, $F(s)$, we use the invariant distribution induced by the transition matrix $[\pi_{ij}]$. For the values of the life-time utility we choose a equispaced grid of 50 points starting in $\underline{V}$ and ending in $\bar{V}$. We choose $\underline{V}$ to be 10% below the autarky level of life-time utility which is capable of sustaining the optimal unconstrained

[20] The evidence suggests that there is no difference in factor shares by nationality of investor (Forsyth and Solomon 1977).

choices of k_f^F and k_o^F for the lowest realization of the shock. We pick a sufficiently high upper bound for V. At this level $(\bar{V})$ the country is financially unconstrained for all shocks. Also, this choice does not restrict the optimal solution since $B\left(\bar{V}, s_j\right) < 0$, for all j.

In simulating the model we use only the specification of the autarky utility level developed in appendix A in which investment is contemporaneous with production. This timing assumption maintains the consistency of production and investment timing decisions in and out of autarky. The alternative scenario, which assumes that investment lags production in autarky, implies a greater marginal impact of either investment flow on the autarky utility level. The end result under this alternative scenario is an additional source of increased relative volatility of non-FDI flows (not reported).

Results

Table 3 presents the results from simulating the model. We run 100 times 111 simulations of 20 years each (the dimension of our sample). All shocks are taken to be country specific. We choose the value of the initial investment I, so that all countries start at a value of $V_0 = \underline{V}$. All statistics are averages across the individual country statistics.

TABLE 3. SIMULATION RESULTS.

	$\theta = .1$			$\rho = .95$			$A = 1.2$	$\alpha = .5$
	$\rho = .95$	$\rho = .5$	$\rho = .1$	$\theta = .1$	$\theta = .5$	$\theta = .9$		
FDI share	.508	.508	.507	.508	.505	.501	.582	.722
CV(FDI)	.065	.031	.019	.065	.082	.085	.032	.077
CV(non-FDI)	.129	.130	.123	.129	.112	.088	.108	.918
CV(FDI/GDP)	.031	.063	.043	.031	.017	.076	.065	.30
CV(non-FDI/GDP)	.100	.122	.116	.100	.061	.091	.130	.905

Notes: CV is the coefficient of variation.

The simulation results suggest that the unconditional volatility of FDI is smaller than that of other flows even when aggregate shocks are persistence. Quantitatively, the model is able to capture a significant differential in volatilities (of either k_i or k_i/y, $i = f, o$) with the ratio of coefficients of variations closely matching the numbers discussed in the

the Introduction.[21]

In these simulations we have assumed that $\alpha_f = \alpha_o$. Recall that Proposition 2 shows that for unconstrained countries this implies that volatilities are equalized. Thus, the volatility differentials observed in Table 3 depend on countries being constrained during the simulation period.

In the simulations lower persistence of shocks leads countries to start-off relatively less constrained. This explains why the FDI share is closer to 50% and the volatilities are reduced to the values that would result in the perfect enforcement case.[22] Lower persistence also decreases the unconditional volatility of the aggregate shock. This is an additional explanation for the drop in the absolute magnitudes of the volatilities when flows are measured in absolute values. One startling result though, is the persistent volatility differential across different values of ρ, independently of how flows are measured.

Lowering the degree of inalienability (i.e. increasing θ) reduces the FDI share. Independently of how inflows are measured, there is a substantial reduction in the volatility differential. The narrowed volatility gap was to be expected from our analytical results with iid shocks.

When FDI has no subsidies ($A = 1$), the simulated FDI shares are somewhat below the empirical values discussed in the Introduction. If, for developing countries, FDI is also driven by tax advantages to FDI ($A > 1$), then the model is able to better fit the observed shares of international flows. This improvement comes with almost no change in relative volatilities. This confirms our initial results for the perfect enforcement case that tax advantages are important determinants of the relative level of FDI versus other capital flows, but not so much of the relative volatilities.

Increasing the production input shares results in flatter marginal product of capital curves. This leads to greater volatility of either FDI and non-FDI inflows. It also leads to greater levels of FDI and non-FDI, but relatively more so of the former. A second effect is that countries start relatively more constrained. This second effect amplifies both the level and volatility differences between FDI and non-FDI flows.

[21] Investment in the model is only 1.5 to 2 times more volatile than output. This lower volatility results mainly from our assumption that capital is fully depreciated.

[22] When there are no financing constraints and shocks are iid, the volatility of either inflows is zero.

4 Empirical Evidence on FDI and Financial Constraints

In this section we investigate the model's new prediction that FDI should be relatively higher for countries with greater financial constraints. Our main dataset is the World Development Indicators from the World Bank (1999b).[23] The sample covers virtually every country with a maximum data span from 1975 to 1997. We use only private flows to these countries and measure FDI and non-FDI flows as percentage of gross private capital flows (normalizing by GDP-PPP adjusted gives similar results).

The crudest test that we can make is to identify financial constraints with income per capita. The International Monetary Fund reports that the 1990-98 average FDI shares of private flows to the middle-income countries was roughly 50% and to low-income non-oil exporters (mineral producers) 70%. These numbers are consistent with Razin et al. (1998) who estimate that the FDI share on private flows to developing countries was about 53% during 1990-95. Figure 3 presents some additional evidence. We first separate the countries into dynamic income groups. For each year we compute the ratio of country i's per capita GDP-PPP adjusted to that of the US. Then, for each year, we break our sample into those countries with no more than 25% of the US per capita GDP, those with more than 75%, and those countries in between. Finally, for each year we compute the simple average of the FDI share in gross flows across countries of the same income group. Figure 3 illustrates that FDI flows are on average more important to low income than to high income countries. (This asymmetric behavior is the main focus of Hull and Tesar (1999).)[24] However, income could in itself proxy for factors unrelated to financial constraints.

Perhaps more problematic in the previous analysis is that GDP per capita does not provide a good exogenous measure of financial constraints. To overcome this difficulty

[23] The WDI reports FDI inflows from Balance of Payments data. This is subject to two major potential problems: (1) that investments are reported in the wrong category, and (2) that the 10% cut-off rule is misleading. The second point is particularly important since this breakdown between FDI and other flows is mostly intended at capturing the existence of a lasting interest in the company, for example, because of the transfer of intangible assets.

[24] This evidence is not in contrast with some studies which find a weak positive association between country size and FDI, since this association typically results from analyzing flows in developed countries alone (e.g. Goldberg and Kolstad (1995)). It is also not in contrast with Kraay et al. (2000) who report facts based on private plus official flows.

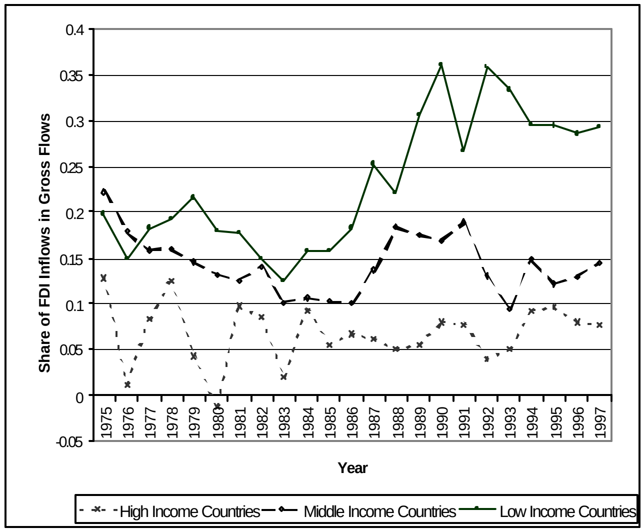

Figure 3: Share of FDI inflows in gross private capital flows, by income group.

we turn to credit ratings for more direct measures of financial constraints. Credit ratings are correlated with measures of financing constraints to the extent that they measure the ability/cost of countries to access international capital markets.

One such measure is Moody's sovereign credit ratings. Moody's ratings are classified as {Aaa,Aa,A,Baa,Ba,B,Caa,Ca,C}, from long term sovereign bonds and notes of the highest quality with interest payments "protected by a large or by an exceptionally stable margin and principal is secure" to a class of bonds with "extremely poor prospects of ever attaining any real investment standing" (Moody's Investors Service 1999). In each category from Aa through Caa Moody's applies numeric modifiers of {1,2,3} from high rank to low rank, which we aggregate. We ignore the rating on debt placed through off-shore banks.

One attractive feature of Moody's credit rating is that these ratings measure only expected credit loss over the life of the security. "They are not intended to measure other risks [...], such as market risk (the risk of loss in the market value of a security)" and "as opinions of long-term credit strength, they are not intended to rise with the business cycle," (Moody's Investors Service 1999). Thus, investment risk (which drives FDI) is not the focus of this credit rating variable. This in principle removes any endogeneity problem from this variable. Nevertheless, we recognize that Moody's sovereign credit rating may be associated with some Macroeconomic factors that affect the desirability of

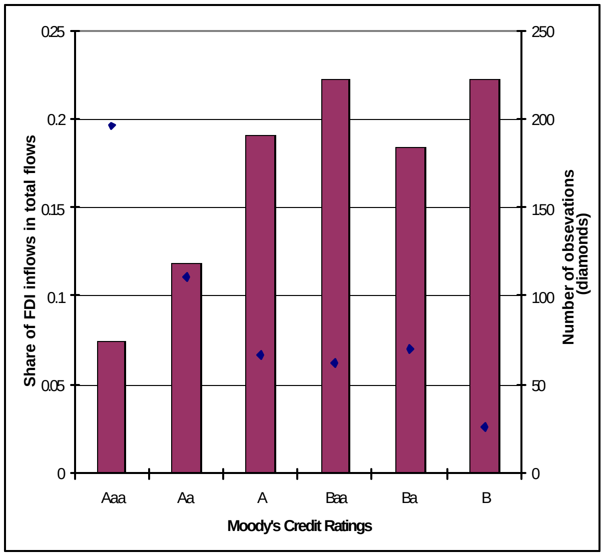

Figure 4: Average share of FDI inflows by Moody's sovereign credit rating. Full sample.

international investors to lend to domestic private and official institutions, which would concurrently influence the capital budgeting decisions of multinational companies.[25]

Figure 4 illustrates the unconditional association between (end of the year) Moody's ratings and FDI flows. In it, we plot the simple average share of FDI inflows on gross private capital flows by credit rating (solid bars). We treat each data point as a country-year observation and aggregate across country-years with identical credit rating.[26] The diamonds in the picture give the number of observations used to compute each average (right axis). The figure suggests that countries with lower credit ratings have greater inflows of FDI.

We now analyze the power of this association in a conditional sense. We also report the same regressions with two other measures of country risk; one by Euromoney and the other by Institutional Investor. In conducting these regressions we condition on a variety of variables that are either relevant to explain FDI or may be captured by our mea-

[25] For example, restrictions on capital flows may be observed in countries with lower credit ratings and with relatively higher FDI levels. Nevertheless, the effect on the relative volatility of the different flows is not immediately implied.

[26] China has had the investment grade rating of 'A' since Moody's started rating its sovereign debt. This rating has been under review for downgrading to 'Baa' during most of this time. Though China seems to have an abnormally high relative level of FDI, excluding it from this picture–and from the empirical analysis altogether–does not affect the qualitative nature of the results.

sures of financial constraints: country size (log GDP per capita PPP adjusted=lgdpc), trade openness (trade volume as percentage of GDP=open), financial development (liquid liabilities as percentage of GDP=findepth),[27] law and order (law), stock market capitalization as percentage of GDP (mktcapg), and the credit rating. Except for credit rating and law and order all variables were obtained from the WDI dataset. The index 'law' was obtained from the International Country Risk Guide of the Political Risk Services Group and measures the willingness to accept and implement laws and adjudicate disputes by the citizens of a country (see also La Porta, Lopez-de-Silanes, Shleifer, and Vishny 1998).

TABLE 1

A. FDI AND SOVEREIGN CREDIT RATINGS.

	Dependent Variable: Share of FDI Inflows to gross flows.					
	I	II	III	IV	V	VI
lgdpc		-.050***		-.053***	-.070***	-.057**
open			-7e-5	7e-5	1e-4	1e-4
Aa	.044***	.048***	.046***	.046***	.056***	.058***
A	.116***	.088***	.116***	.082***	.081***	.130***
Baa	.147***	.098***	.146***	.096***	.093***	.088***
Ba	.108***	.060**	.106***	.060**	.060*	.063*
B	.147***	.097***	.144***	.098***	.093**	.092**
findepth				1e-4		
law					.007	
mktcapg						2e-4
cons	.075***	.549***	.079***	.568***	.701***	.617***
R^2	.17	.20	.17	.19	.22	.23
N	532	532	532	488	448	364

Notes: Please refer to panel B of Table 1.

From panel A in Table 1 we see that these variables account for a significant portion of the total variation in FDI: 17%-23%. In fact, the explanatory power comes exclusively from the credit rating variable. The addition of other variables, though statistically significant in some cases, does not contribute to an important increase in the explanatory

[27] Our choice of 'findepth' as an indicator of financial development follows Beck, Levine and Loayza (1999). When liquid liabilities (or M3) is not available Money and Quasi-money as percentage of GDP (M2) was used (see Beck, Levine and Loayza (1999)). An alternative measure of financial depth is the amount of credit to the private sector as a percentage of GDP. Using this variable instead of Liquid Liabilities produced similar results, which we omit.

power of the regression. Also, the effect is economically significant: going from 'Aaa' rating to 'B' rating increases the share of FDI in gross private flows by 9-14 percentage points. Furthermore, the slopes associated with the credit rating dummy variable display a quasi-monotonic behavior.[28] To conclude, we do not claim to explain most of the variation in FDI based on default risk, but we do think that there is a strong negative link between FDI and the quality of sovereign credit (see also Hausmann and Fernández-Arias (2000)).

The negative sign of 'lgdpc' confirms our previous unconditional analysis. Lane and Milesi-Ferretti (2000) document a negative conditional correlation between GDP per capita and the *stock* of FDI to total private inflows.

It is interesting to note that the development of financial markets as measured by 'findepth', or the stock market capitalization as percentage of GDP, does not eliminate the explanatory power of our measure of credit rating. This is important because it could be argued that credit rating proxies for underdeveloped capital markets: if there is limited scope for diversification by international investors using marketable securities they will supply relatively more FDI.

Finally, the measure of law and order is also insignificant and leaves the estimates on the credit rating dummies almost unchanged.

To assess the robustness of our analysis we also conduct the estimations with two broad measures of country risk: one by Euromoney, 'EM', and another by Institutional Investor, 'iinv'. 'EM' measures political risk, access to short term financing, the likelihood of debt rescheduling, and economic risk; 100 being the safest and 0 the riskiest. Data for 'EM' is available for 1996 and 1997. 'iinv' rankings are based on a survey of international bankers, and are designed to capture political, economic, and financial risks, that might lead to credit default; 100 is the least risky and 0 the riskiest. Data for 'iinv' is available from September of 1979 through September of 1997 for most countries. (Using the numbers published in March by Institutional Investor results in very similar estimations.)

The results are shown in panel B of Table 1 below. The regressions with 'EM' and 'iinv' broadly confirm the previous results that country credit ratings are strongly negatively associated with FDI. By construction, these measures of *country risk* are much

[28] A Wald test of the null hypothesis of equal parameters (on the dummy variables) against the alternative one-sided hypothesis of increasing parameters rejects the null in all four regressions at the 1% level.

broader then Moody's *sovereign default risk* (hence, more subject to endogeneity problems). Even so, they show a very strong correlation; the Spearman correlation coefficient between 'moody' and 'EM' is .89 ('moody' is a variable that takes the value of 6 for a country with ranking Aaa, 5 if its ranking is Aa, and so on), between 'iinv' and 'moody' is .95, and between 'iinv' and 'EM' is .97. These facts could explain why these different ratings show such strong association with FDI, but also why output is no longer statistically significant when we use EM or iinv instead of the dummy variables from Moody's.[29] Being broader measures of country risk they are also highly correlated with the index 'law' (linear correlations of .73 in absolute value) though not so much with stock market capitalization (linear correlations below .48 in absolute value). When we ignore the measures of country risk and regress the FDI share on gross flows onto income, trade openness, and each of the other variables separately, only 'law' comes significant, but with a positive coefficient. A positive sign on 'law' indicates that this variable could proxy for better property rights protection or commitment technologies.

These measures of country risk rating still reveal an economically significant impact on FDI. For example, going from the best overall rating of 100 to the lowest possible rating increases the FDI share in gross private flows by 10-40 percentage points according to 'EM' and by 10 percentage points according to 'iinv'. The estimated impact of Institutional Investor's country risk rating on the share of FDI is similar to that of Moody's sovereign credit rating.

Finally, in both panels of Table 1, openness of a country does not seem to be important in explaining FDI flows. It is however hard–and is not the purpose of this paper–to say that trade barriers do not explain FDI flows. The only purpose of including this variable is to show that the robustness of our results survives including a measure of trade barriers. In other robustness checks we have also estimated these regressions including time dummies with similar results. Excluding the OPEC countries in our sample also does not affect the results.

[29] Note also that (i) the regression of the FDI share on lgdpc produces a slope coefficient of -.028 significant at the 1% level, but an R^2 of only .5%, and (ii) the correlation coefficient between lgdpc and EM is 0.87, and that between lgdpc and iinv is 0.75.

Table 1

B. FDI and Sovereign Credit Ratings.

Dependent Variable: Share of FDI Inflows to gross flows.

	I	II	III	IV	V	I	II	III	IV	V
lgdpc	.010	.024	.023	-.014	-.041	-.016	-.021	-.022**	-.046**	-.026**
open		-3e-4	-4e-4	-6e-4	-5e-4		3e-4	2e-4*	1e-4	-6e-6
EM	-.004**	-.004***	-.004***	-9e-4	-.001					
iinv						-.001***	-.001**	-.001***	-.001***	-.001
findepth			3e-4					3e-4		
law				-.008					.026**	
mktcapg					3e-4					2e-4
cons	.348	.268	.265	.438*	.620**	.333***	.371**	.357***	.505***	.429***
R^2	.13	.14	.12	.10	.13	.03	.03	.02	.05	.07
N	201	196	185	156	150	1517	1498	1433	1098	594

Notes: OLS estimates. 'lgdpc' is the log of GDP per capita PPP adjusted, and 'open' is the trade volume as percentage of GDP. EM refers to Euromoney's country rating. 'iinv' is Institutional Investor's September country credit rating. A high number means a good credit rating. Moody's credit rating is the end of calendar year rating of debt placed through domestic banks. 'findepth' is liquid liabilities (M3) as % of GDP or money and quasi-money as % of GDP when M3 is not available. 'law' is the law and order rating in the International Country Risk Guide of the PRS Group. High points means that there is a strong law and order tradition. 'mktcapg' is the stock market value as % of GDP. A '***' indicates significance at the 1% (two-sided) level, '**' at 5% level, and '*' at 1% level. 'N' is the number of country-year observations. White corrected standard errors.

5 Final Remarks

FDI flows to developing countries are less volatile than other financial flows. Moreover, the share of FDI to financially constrained countries is larger than that to financially unconstrained countries. We rationalize these facts in a model where international contracts are subject to imperfect enforcement and FDI is inalienable. These features combine to give a risk sharing advantage of FDI over other capital flows. This risk sharing advantage translates into a lower default premium on FDI and a smaller response to changes in a country's financing constraint.

The model suggests that the greater volatility of non-FDI flows, usually negatively portrayed in the media, is a natural outcome of the optimal choices of international investors. It also suggests that the relatively larger flows of FDI to less developed countries are a reflection of their poor financial status. This does not mean that FDI is bad for these economies, but that FDI is all that they can get. This is in contrast with the view that FDI is preferable, as a means of financing less developed countries. From a normative standpoint the model suggests that countries trying to expand their access to international capital markets should concentrate on developing credible enforcement mechanisms instead of trying to get more FDI. The model also shows that the composition of international flows depends on the physical capital shares of the different investments.

We do not claim that this mechanism is the only driving force of FDI and non-FDI flows to less developed countries. In particular, the model intentionally lacks some relevant explanatory variables as capital controls, geographical issues or other forms of comparative advantages. The model is very stylized and could be extended along several dimensions: e.g. allow for an elasticity of intertemporal substitution different than 1 and partial depreciation of capital. All these things would enrich the model, but make our argument less clear. One unrealistic feature of the current setup is that countries grow to become unconstrained and that this state is absorbing. A simple way to eliminate this absorbing state is to allow exogenous separation during the contract's life-time. This alternative specification preserves the main qualitative results of the paper.

Since the model helps us understand some features of the composition of international flows, one interesting question for future research is whether it can account for properties of long run versus short run flows. Additionally, we would like to know what features of the model could be useful in trying to understand the *levels* of international capital flows. This is particularly important given the observed steep trend in FDI flows to developing countries.

This paper relates to models of risk sharing based on imperfect enforcement (e.g. Kehoe and Levine 1993). Calibrated versions of these models tend to yield very dramatic implications for international risk sharing. The lack of enforcement typically forces countries to borrow very limited amounts as if they were always on the verge of opting out and going into autarky (Marcet and Marimon 1992, and Kehoe and Perri 1998). This is because, once capital accumulation is allowed in autarky, it becomes very difficult to sustain borrowing and lending among countries (similar to the Bulow and Rogoff (1989) curse). In a certain sense these models provide an answer to Lucas' (1990) question, but an extreme one. We have argued that there are a variety of international financial instruments differentiated by their risk sharing potential. Assets that are inalienable–and thus useless under autarky–can be used to provide greater insurance and market integration under imperfect enforcement of contracts. Analyzing these issues in the context of those models seems an interesting research avenue.[30]

[30] Alternative analysis of heterogeneous international capital goods is done in Hull and Tesar (1999) and Razin et al (1998).

A Autarky Life-time Utility

In this appendix we explicitly derive the domestic investor's life-time utility in the autarky regime under two alternative specifications of the efficiency of investment. We make extensive use of the assumptions of log-utility and full depreciation.

Case 1. Under the assumption that domestic investment under autarky is equally efficient as foreign investment, and so can be made in the same time period, we have that:

$$U(k_f, k_o, s) = \ln\left(\theta A s k_f^{\alpha_f} + s k_o^{\alpha_o}\right) + \frac{1}{1+r} E\left[\bar{U}(s') \,|s\right],$$

where $\bar{U}(.)$ is given by the recursion:

$$\bar{U}(s) = \max_{k_o \geq 0} E\left[\ln\left(s' k_o^{\alpha_o} - k_o\right) + \frac{1}{1+r}\bar{U}(s') \,|s\right].$$

The first order condition for this problem is:

$$E\left[\frac{\alpha_o s' k_o^{\alpha_o} - k_o}{s' k_o^{\alpha_o} - k_o} |s\right] = 0.$$

Guess that $k_o = \phi_s k_o^{\alpha_o}$, or that $k_o = \phi_s^{1/(1-\alpha_o)}$. Then the first order condition becomes an equation in ϕ_s, for each s:

$$(1-\alpha_o) E\left[\left(1 - \phi_s/s'\right)^{-1} |s\right] = 1.$$

Let $\Upsilon(\phi) = (1-\alpha_o) E\left[(1-\phi/s')^{-1} |s\right]$ for fixed s. We have that $\Upsilon(0) = 1 - \alpha_o < 1$, and $\Upsilon'(\phi) = (1-\alpha_o) E\left[\left((s')^2 - \phi s'\right)^{-2} |s\right] > 0$. Hence, if a solution ϕ_s exists it is unique. Relative to (6) we have $d_0 = 0$, $d_1 = 1$, and $\Lambda(s) = \ln(s) + \frac{1}{1+r} E\left[\bar{U}(s') \,|s\right]$.

Case 2. The alternative scenario that we consider is that domestic investment under autarky is less efficient than foreign investment in the sense that it must be made with one period lag. Thus, the value of the host country's representative consumer under autarky is given by:

$$U(k_f, k_o, s) = \max_{k_o', c \geq 0}\left[\ln(c) + \frac{1}{1+r} E\bar{U}(k_o', s')\right]$$

subject to

$$\theta s A k_f^{\alpha_f} + s k_o^{\alpha_o} = c + k_o',$$

and the Bellman equation:

$$\bar{U}(k_o, s) = \max_{k_o' \geq 0}\left[\ln\left(s k_o^{\alpha_o} - k_o'\right) + \frac{1}{1+r} E\bar{U}(k_o', s')\right].$$

It is easy to check that the functional form $U(.)$ in (6) is obtained when $d_1 = \frac{\bar{d}_1}{\alpha_o}$, $\bar{d}_1 = \frac{\alpha_o}{1-\beta\alpha_o}$, $\Lambda(s) = d_2 \ln(s)$, with $d_2 = \frac{1+\beta\bar{d}_1}{1-\beta\rho}$,

$$(1-\beta) d_0 = \beta\bar{d}_1 \ln\left(\beta\bar{d}_1\right) - \left(1+\beta\bar{d}_1\right)\ln\left(1+\beta\bar{d}_1\right) + \beta d_2 (1-\rho)\ln(\bar{s}),$$

and $\beta = 1/(1+r)$.

The main difference between the two possible scenarios is that in case 2, $U(.)$ responds more to changes in capital flows since $d_1 = \bar{d}_1/\alpha_o = 1/(1-\beta\alpha_o) > 1$.

B Proof of Propositions

Proof of Proposition 2 . Letting $\psi(s') = 0$ for all s' in equations (7) and (8) we obtain the first order conditions: $E(s'|s) A\alpha_f k_f^{\alpha_f - 1} = 1$, and $E(s'|s)\alpha_o k_o^{\alpha_o - 1} = 1$. The optimal choices $\left(k_f^F, k_o^F\right)$ can be easily computed from these conditions. Thus there is no default premium. Also, countries are heterogeneous only through different realizations of the aggregate shock. Using these first order conditions we can compute the ratio of input elasticities to changes in s:

$$\frac{\frac{dk_f}{ds}\frac{s}{k_f}}{\frac{dk_o}{ds}\frac{s}{k_o}} = \frac{1-\alpha_o}{1-\alpha_f}.$$

Let $\mu(s)$ be the time series sample probability of shock s for a given country. The sample coefficient of variation of FDI to that country is

$$\frac{1}{E(k_f)}\left(\int (k_f - E(k_f))^2 \mu(ds)\right)^{1/2} = \frac{1}{E(s)}\left(\int \left(\frac{\Delta k_f}{\Delta s}\frac{E(s)}{E(k_f)}\right)^2 (\Delta s)^2 \mu(ds)\right)^{1/2},$$

with $\Delta X = X - E(X)$. Similarly for the coefficient of variation of k_o. The result now follows by approximating $(\Delta k_f/\Delta s)(E(s)/E(k_f))$ with the input elasticity (i.e. assuming a time series sequence with small dispersion of shocks). ■

Proof of Proposition 3. Consider the first order conditions (7) and (8) and replace the value of U_{k_f} and U_{k_o} by their expressions to get:

$$\frac{1}{A\alpha_f k_f^{\alpha_f - 1}} = E(s'|s) - \theta\Psi(V,s) \tag{9}$$

$$\frac{1}{\alpha_o k_o^{\alpha_o - 1}} = E(s'|s) - \Psi(V,s) \tag{10}$$

with $\Psi(V,s) = E[\psi(s')|s] d_1 / \left[(1+r)\left(\theta A k_k^{\alpha_f} + k_o^{\alpha_o}\right)\right] \geq 0$. Since $E[\psi(s')|s]$ is common to both conditions and determines the extent of financing constraints, either both forms of capital are constrained or none. Finally, if $E[\psi(s')|s] > 0$, so that the domestic consumer is financially constrained, we must have $\frac{1}{A\alpha_f k_f^{\alpha_f - 1}} > \frac{1}{\alpha_o k_o^{\alpha_o - 1}}$. That is, the default premium of FDI is lower than that of non-FDI. Thus when $A \geq 1$, and $\alpha_f = \alpha_o$ we get that $k_f > k_o$. ■

Proof of Proposition 4. Consider conditions (9) and (10) in the proof of Proposition 3. Note that with iid shocks the current shock does not affect the value of capital and countries are heterogenous with respect to V only. For each time period that the country is unconstrained $\Psi(V)=0$, and the elasticities of capital inputs to changes in V are both zero. When $\Psi(V)>0$,

$$\frac{\frac{dk_f}{dV}\frac{V}{k_f}}{\frac{dk_o}{dV}\frac{V}{k_o}}=\theta\frac{1-\alpha_o}{1-\alpha_f}\frac{A\alpha_f}{\alpha_o}\frac{k_f^{\alpha-1}}{k_o^{\alpha-1}}=\theta\frac{1-\alpha_o}{1-\alpha_f}\frac{E(s')-\Psi(V)}{E(s')-\theta\Psi(V)},$$

where we have used (9) and (10) to get to the second equality. When $\alpha_f\leq\alpha_o$ this ratio is less than one if, and only if $\theta<1$, since the numerator and denominator are both positive. Let $\mu(V)$ be the sample time series density of realizations of V for a given country. With small variation in V, we can approximate $(\Delta k_f/\Delta V)(E(V)/E(k_f))$ with the input elasticity to get

$$\begin{aligned}\text{Coef. Variation}(k_f) &= \frac{1}{E(V)}\left(\int\left(\frac{\Delta k_f}{\Delta V}\frac{E(V)}{E(k_f)}\right)^2(\Delta V)^2\mu(dV)\right)^{1/2}\\ &< \frac{1-\alpha_o}{1-\alpha_f}\frac{1}{E(V)}\left(\int\left(\frac{\Delta k_o}{\Delta V}\frac{E(V)}{E(k_o)}\right)^2(\Delta V)^2\mu(dV)\right)^{1/2}\\ &= \frac{1-\alpha_o}{1-\alpha_f}\text{Coef. Variation}(k_o),\end{aligned}$$

proving the result. ■

C Solution Method

In this appendix we describe the solution method used to compute the optimal contract.

Method to Solve for the Value Function and Decision Rules

1. Create a uniform grid for $V(s)$. Let the grid be $\mathcal{V}=\{V_1,V_2,...,V_M\}$, with generic element V_j, and with the properties that $V_1=\underline{V}$, and $V_M=\bar{V}$. We pick $\bar{V}$ such that it does not bind on any of our simulations. Let the grid for s be $S=\{s_1,s_2,...,s_N\}$.

2. The first step is to construct a $(M\times N)$ matrix B^F that solves the perfect enforcement problem. For each s construct the short run profit function

$$p_s=E_s(s')\left(A\left(k_f^F\right)^{\alpha_f}+\left(k_o^F\right)^{\alpha_o}\right)-\left(k_f^F+k_o^F\right),$$

evaluated at the optimal capital levels for the perfect enforcement case (these are described in Proposition 2). Let $\mathcal{P}$ be a $(N\times M)$ matrix whose (i,j) element is $\mathcal{P}_{ij}=p_{s_i}$. Let Ξ be a $(N\times M)$ matrix whose (i,j) element is $\Xi_{ij}=V_j$. Finally, let $\Pi=[\pi_{ij}]$ be the transition matrix for the shocks. Define $\mathcal{M}=I_N-\beta\Pi$, where I_N is an identity matrix of size N. Then,

$$B^F=\left(\mathcal{M}^{-1}\left(\mathcal{P}-\exp^{(1-\beta)\Xi}\right)\right)'.$$

3. B^F is used to start the iterations on the function B.

4. Consider iteration $n \geq 1$. (At iteration $n = 1$ the guesses for the decision rules at $n = 0$, are all set to 1.) Fix the current state (V_j, s_i). We proceed by using another loop.

    (a) Consider iteration $k \geq 1$.

    (b) Fix next period's shock as well, s'_l.

    (c) Assume that the decision rule from the previous iteration is optimal for all other future shocks (s'_{-l}). That is, let $V^{k,n-1}\left(s'_{-l}\right) = V^{n-1}\left(s'_{-l}\right)$, for $k = 1$ and $V^{k,n-1}\left(s'_{-l}\right) = V^{k-1,n-1}\left(s'_{-l}\right)$, for $k > 1$. (For simplicity we omit the dependence of V^n and B^n on s_i, V_j.) Similarly, let $B^{k,n-1}\left(s'_{-l}\right) = B^{n-1}\left(s'_{-l}, V^{n-1}\left(s'_{-l}\right)\right)$, for $k = 1$, and $B^{k,n-1}\left(s'_{-l}\right) = B^{k-1,n-1}\left(s'_{-l}, V^{k-1,n-1}\left(s'_{-l}\right)\right)$, for $k > 1$.

    (d) Using grid search find the new optimal value for $V^{k,n-1}(V_j, s_i, s'_l)$. Repeat the procedure for all l.

    (e) Check convergence by comparing the matrices $V^{k,n-1}(s'_l)$, and $V^{k-1,n-1}(s'_l)$ (use $V^{0,n-1} = V^{n-1}$ if $k = 1$). When convergence is attained let $V^n(V_j, s_i, s'_l) = V^{k,n-1}(V_j, s_i, s'_l)$, for all l. Similarly for $B^n(V^n(V_j, s_i, s'_l), s'_l)$.

5. Repeat the procedure for all s, and V. Check convergence by comparing the matrices $B^n(V_j, s_i)$, and $B^{n-1}(V_j, s_i)$.

References

[1] Albuquerque, Rui, and Hugo Hopenhayn (2001), "Optimal Lending Contracts and Firm Dynamics," working paper, University of Rochester.

[2] Albuquerque, Rui, and Sérgio Rebelo (2000), "On the Dynamics of Trade Reforms," *Journal of International Economics*, Vol. 51:21-48.

[3] Barro, Robert and Xavier Sala-i-Martin (1995), Economic Growth. McGraw-Hill Inc.

[4] Beck, Thorsten, Ross Levine, and Norman Loayza (1999), "Finance and the Sources of Growth," Carlson School of Management working paper.

[5] Bulow, Jeremy and Kenneth Rogoff (1989b), "Sovereign Debt: Is to Forgive to Forget?," *American Economic Review*, 79:43-50.

[6] Caves, Richard (1982), Multinational Enterprise and Economic Analysis. Cambridge, MA, Harvard University Press.

[7] Caves, Richard (1996), Multinational Enterprise and Economic Analysis. Second Edt. Cambridge University Press.

[8] Chuhan, Punam, Gabriel Perez-Quiros, and Helen Popper (1996), "International Capital Flows: Do Short-term Investment and Direct Investment Differ?," World Bank Policy Research Working Paper # 1669.

[9] Claessens, Stijn, Michael Dooley, and Andrew Warner (1995), "Portfolio Capital Flows: Hot or Cold?" *The World Bank Economic Review*, 9:153-174.

[10] Cooley, Thomas F. and Edward C. Prescott (1995), "Economic Growth and Business Cycles." In Thomas F. Cooley, ed., *Frontiers of Business Cycle Research*. Princeton University Press: Princeton, New Jersey.

[11] Eaton, J. and Raquel Fernández (1995), "Sovereign Debt," Handbook of International Economics, vol. 3, eds. G. Grossman and K. Rogoff. North Holland.

[12] Eaton, Jonathan, and Mark Gersovitz (1984), "A Theory of Expropriation and Deviations from Perfect Capital Mobility," *The Economic Journal* 94:16-40.

[13] Forsyth, D. and R. E. Solomon (1977), Choice of Technology and Nationality in manufacturing in a developing country," *Oxford Economic Papers* 29:258-282.

[14] Froot, Kenneth A., and Jeremy Stein (1991), "Exchange Rates and Foreign Direct Investment: An Imperfect Capital Markets Approach," *Quarterly Journal of Economics*, 106: 1191-217.

[15] Goldberg, Linda, and Charles Kolstad (1995), "Foreign Direct Investment, Exchange Rate Variability and Demand Uncertainty," *International Economic Review*, 36:855-873.

[16] Green, E. (1987) "Lending and the Smoothing of Uninsurable Income," in *Contractual Arrangements for Intertemporal Trade,* University of Minnesota Press, Minneapolis, Minnesota.

[17] Hart, Oliver and John Moore (1994), "A Theory of Debt Based on the Inalienability of Human Capital," *Quarterly Journal of Economics*, November, 841-879.

[18] Hausmann, Ricardo, and Eduardo Fernández-Arias (2000), "Foreign Direct Investment: Good Cholesterol?" Inter-American Development Bank, WP #417.

[19] Hull, Leslie, and Linda L. Tesar (1999), "Risk, Specialization and the Composition of International Capital Flows," working paper, University of Michigan.

[20] Kehoe, Patrick, and Fabrizio Perri (1998), "International Business Cycles with Endogenous Incomplete Markets," Federal Reserve Bank of Minneapolis Working Paper.

[21] Kraay, Aart, Norman Loayza, Luis Serven, and Jaume Ventura (2000), "Country Portfolios," NBER working paper #7795.

[22] La Porta, Rafael, Florencio Lopez-de-Silanes, Andrei Shleifer, and Robert Vishny (1998), "Law and Finance," *Journal of Political Economy* 106:1113-1155.

[23] Lane, Philip, and Gian Maria Milesi-Ferretti (2000), "External Capital Structure: Theory and Evidence," IMF working paper #152.

[24] Lipsey, Robert E. (1999), "The Role of Foreign Direct Investment in International Capital Flows," NBER Working Paper # 7094.

[25] Lipsey, Robert E. (2001), "Foreign Direct Investment in Three Financial Crisis," NBER Working Paper # 8084.

[26] Lucas, Robert E. (1990), "Why Doesn't Capital Flow from Rich to Poor Countries," *American Economic Review Papers and Proceedings*, 80:92-96.

[27] Mansfield, Edwin, and Anthony Romeo (1980), "Technology Transfer to Overseas Subsidiaries by US-Based Firms," *Quarterly Journal of Economics*, 737-750.

[28] Mansfield, Edwin, Mark Schwartz and Samuel Wagner (1981), "Imitation Costs and Patents: An Empirical Study," *The Economic Journal*, 91:907-918.

[29] Marcet, Albert and Ramon Marimon (1992), "Communication, Commitment, and Growth," *Journal of Economic Theory*, 58, 219-249.

[30] Moody's Investors Service (1999), "Ratings and Ratings Actions," in http://www.moodys.com/ratings/ratdefs.htm.

[31] Phelan, Christopher (1995), "Repeated Moral Hazard and One-Sided Commitment," *Journal of Economic Theory* 66: 488-506.

[32] Razin, Assaf, Efraim Sadka, and Chi-Wa Yuen (1998), "A pecking order of capital inflows and international tax principles," *Journal of International Economics* 44:45-68.

[33] Sarno, Lucio, and Mark Taylor (1999), "Hot Money, Accounting Labels and the Permanence of Capital Flows to Developing Countries: an Empirical Investigation," Journal of Development Economics, 59:337-364.

[34] Spear, E. and S. Srivastava (1987), "On Repeated Moral Hazard With Discounting," *Review of Economic Studies*, 54, 599-617.

[35] Stokey, Nancy L. and Robert E. Lucas, Jr. with Edward C. Prescott (1989), *Recursive Methods in Economic Dynamics*, Harvard University Press.

[36] Tauchen, George, and Robert Hussey (1991), "Quadrature-Based Methods for Obtaining Approximate Solutions to Nonlinear Asset Pricing Models," *Econometrica* 59:371-396.

[37] Thomas, Jonathan and Tim Worral (1994), "Foreign Direct Investment and the Risk of Expropriation," *Review of Economic Studies* 61: 81-108.

[38] UNCTAD (1998), "World Investment Report: Trends and Determinants, Overview," United Nations. New York.

[39] UNCTAD (1999), "Comprehensive Study of the Interrelationship between Foreign Direct Investment (FDI) and Foreign Portfolio Investment (FPI)," mimeo UNCTAD/GDS/DFSB/5.

[40] World Bank (1999a), "Global Development Finance," The World Bank. Washington D.C.

[41] World Bank (1999b), "World Development Indicators," The World Bank. Washington D.C.