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What Makes Hot Money Hot? The Relative Volatility of International Flows of Debt and Equity Capital*

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This paper is concerned with the relative volatility of international flows of debt and equity capital. It is shown that if foreign investors are less well informed about the domestic economy than domestic investors, then international flows of debt capital will be more volatile than flows of equity capital in the sense that the proportional change of foreign bondholdings in an economy in response to a change in that economy's economic prospects will be greater than the proportional change in foreign stockholdings. This is shown to be consistent with the behavior of international flows of debt and equity capital during the Asian crisis.

1. Introduction

The recent crises in Asia, Russia, and Latin America have given rise to renewed concern about the effects of the free flow of capital between countries,[1] particularly in the case of countries with inadequately developed capital markets. Some countries have even responded to capital outflows by re-imposing

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[1]"While there is general agreement about the potential benefits that well-functioning global capital markets can generate, there has been much more controversy about the market's ability both to generate a sustainable flow of capital to emerging markets and to evaluate and price the credit risks associated with different borrowers." (IMF, 1998), p. 67.

Table 1. International Capital Flows 1990–97[2]

	Asia	Emerging Market	Affected Asia[1]
Aggregate flow	$420.3 billion	$1210.7 billion	$276.8 billion
Composition of flows:			
Portfolio investment	13.3%	34.8%	31.0%
Bank loans	18.4	17.3	44.0
FDI	68.3	47.9	25.0

[1]Indonesia, Korea, Malaysia, the Philippines, Thailand.
[2]Source IMF (1998).

restrictions.[2] Even before the recent crises, distinguished economists had called for taxes and regulation to discourage "speculative capital flows".[3] Table 1 reports the magnitudes of the different components of the capital flow to Asia and the emerging markets during the period 1990–1997 as reported by the IMF (1998). It is striking that, while Foreign Direct Investment accounted for 68.3 percent of total flows to Asia, they accounted for only 25 percent of the flows to the countries in Asia that were affected by the Asian financial crisis. On the other hand, the shares of the flows accounted for by bank loans[4] and by portfolio flows, which include purchases and sales of debt and equity securities, were much greater for the countries affected by the crisis than for Asia as a whole. Table 2 provides evidence on the volatility of the different components of the capital flows in the form of coefficients of variation. It is clear that Foreign Direct Investment flows tend to be the most stable, that portfolio investment flows are the next most stable, and that the least stable category of flow is represented by bank loans. It is perhaps not surprising that Foreign Direct Investment flows are relatively stable since it is expensive to cancel committed investment projects and, once completed, such projects are essentially irreversible. Therefore in this paper we are concerned with understanding the relative volatility of international flows of debt and equity capital which includes

[2]In 1991 Chile introduced a one-year mandatory non-interest-bearing reserve requirement on all foreign borrowing, set initially at 20 percent and then raised to 30 percent; in addition, only banks and firms with credit ratings as high as the government itself were allowed to borrow abroad. Brazil tightened controls on short term inflows in March 1998, and Malaysia introduced strict capital controls in September 1998, in the wake of the Asian crisis.

[3]E.g. Summers and Summers (1990) and Tobin (1978), Stiglitz (1998).

[4]The International Monetary Fund breaks private capital flows into Net Foreign Direct Investment, Net Portfolio Investment, and Other. In the 1990's "Other" largely consisted of bank lending (IMF, 1998, p. 12) and for simplicity we label it as such.

Table 2. Volatility of Components of International Capital Flows 1990–97[2]

	Coefficients of Variation		
	Asia	Emerging Markets	Affected Asia[1]
Portfolio investment	1.34	0.57	0.63
Bank loans	2.48	1.43	1.48
FDI	0.56	0.59	0.21

[1]Indonesia, Korea, Malaysia, the Philippines, Thailand.
[2]Source IMF (1998).

both portfolio investment and bank lending. Our analysis is based on an extension of the models of Brennan and Cao (1996, 1997) which focus on the consequences of information asymmetry between investors.[5]

It is commonly suggested that capital flows that are invested in short maturity assets are more volatile than flows that are invested in longer term assets such as bonds or equity.[6] One reason that holdings of short maturity debt securities may be more volatile than holdings of longer maturity debt contracts or equity is the possibility of bank runs.[7] To the extent that short maturity debt securities are liabilities of banks and there is no lender of last resort, occasional bank runs would give rise to big negative capital flows.[8] This would imply negative skewness in capital flows but would not explain large positive inflows. A second possibility is that markets for short term debt securities are more liquid than markets for longer term debt and equity; since the costs of portfolio adjustment would be lower for these securities we might expect to see their holdings more responsive to changes in expected returns relative to other securities. In this paper we pursue a related but different explanation. We argue that *equilibrium*

[5]Chari and Kehoe (1996) construct a model of (debt) capital flows based on the herding model of Bikhchandani *et al.* (1992). Calvo and Mendoza (1998) present a model of (equity) capital flows in which volatility is also created by herding; they argue that opportunities for international diversification reduce incentives to become informed which makes herding more likely.

[6]For example, Michel Camdessus, Managing Director of the International Monetary Fund, "We need to push ahead with capital flow liberalisation but in an orderly fashion. The last thing you must liberalise is the very short term capital movements". *Financial Times*, February 4, 1998.

[7]See Diamond and Dybvig (1986), and Chari and Jagannathan (1988). Chari and Kehoe (1996) develop a model of hot money that is based on bank runs precipitated by informational cascades. Kaminsky and Reinhart (1999) argue that the roots of the Thai, Korean and Indonesian crises lay in systemic banking problems.

[8]That there was an element of the bank run in the recent Asian crisis seems beyond dispute. "Banks' weak fundamentals combined with a lack of transparency and of decisive response from the authorities fueled the reluctance of foreign creditors to roll over short term loans to banks" (IMF, 1998).

or desired holdings of debt securities, and particularly of short term debt securities, are likely to be more volatile than holdings of equity securities. Brennan and Cao (1997) have shown that foreign investors are likely to be net sellers, even of equity securities, when there is bad news, and found evidence of this for emerging markets. In this paper we argue that this tendency to sell on bad news and buy on good news may be re-inforced when the holdings are of debt rather than of equity securities, particularly when the maturity of the debt is short.

Some intuition for the greater volatility of debt holdings can be gained from the *partial equilibrium* argument that a debt security becomes *more* risky as the value of the issuer declines. A bondholder who wishes to maintain constant risk exposure must reduce the number of bonds he owns as the value of the issuer, and hence its creditworthiness declines; he will therefore tend to be a net seller on bad news and a purchaser on good news.[9] However this intuition, while superficially plausible, cannot be the explanation for short term international capital outflows on bad news, for it does not explain who purchases the bonds that are sold — this requires a general equilibrium argument that we will develop below. Following Brennan and Cao (1997), our setting is one in which foreign investors are assumed to be less well informed about the domestic economy than are domestic investors. Such an assumption seems especially appropriate for emerging markets which often lack reliable official statistics.[10] Under this assumption we show that, following the announcement of bad news, foreign investors tend to reduce their exposure to the domestic economy as measured by the sensitivity of the value of their asset holdings to changes in the domestic market portfolio. This causes them to reduce their holdings of assets such as unlevered equity whose payoffs are linear functions of the market portfolio, since an unchanged holding would leave their risk exposure unchanged also. However, the situation for debt holdings is rather different, since an unchanged position in debt leads to an increase in the sensitivity of the value of the position to changes in the domestic market portfolio: the debt becomes more risky. As a result, to achieve a given reduction in risk, foreigners must reduce their holdings of debt securities by a larger amount than would be required for a portfolio of unlevered equity. Moreover, this effect becomes more pronounced the riskier the debt becomes. As a result, foreign holdings of debt securities can become extremely volatile as the risk of the

[9]*The Economist* (June 12, 1999), "The Price of Uncertainty" recognizes that banks which use Value at Risk methods will be forced to sell assets as risks rise, and this will tend to force down asset prices.
[10]*The Economist* (January 30, 1998) likens Asian economies to "Opacia" a fictional economy which, as the name suggests, lacks transparency.

economy rises, giving rise to a balance of payments crisis. Section 2 discusses the data on capital flows to emerging markets and Asia in recent years and summarizes recent studies relating capital flows to informational considerations. Section 3 presents the basic model, Sec. 4 presents some numerical examples, and Sec. 5 considers the determinants of flows of debt, equity and bank loan capital to Indonesia, Korea and Thailand during the 1990's in light of the theory.

2. Information and Capital Flows

The recent history of foreign capital flows to Asia and the emerging markets is well summarized in IMF (1998, p. 12):

> "portfolio flows to the emerging markets have been volatile. From a peak of 104 billion in 1993, for example, they fell to less than one-fourth of this level in 1995 in the aftermath of the Mexico peso crisis in 1995, then more than doubled to 50 billion in 1996. During 1997 portfolio flows shrank by 14 percent to 43 billion. "Other flows", which largely consisted of bank lending, were negative — that is, there were net outflows of 7.3 billion during 1997. This reflected a massive turnaround — from net bank lending inflows of over 70 billion in 1995 and in 1996.
>
> The precipitous decline of almost 100 billion in net private capital flows to Asia in 1997 reflected a 75 billion turnaround in bank lending flows and 22 billion in portfolio flows, while FDI flows to the region remained stable. Most of the declines in total flows to the Asian region reflected declines in flows to the affected Asian countries — Thailand, Malaysia, the Philippines, Indonesia and Korea — where net inflows of 73 billion in 1996 were replaced by net outflows of 11 billion in 1997. Most of the turnaround to these countries in turn arose from a 73 billion turnaround in net bank lending flows, with the sharpest outflows recorded from Thailand and Korea of some 18 billion each. Portfolio flows to the affected countries fell but remained positive while FDI flows remained resilient."

The model that we shall develop in the following section predicts that as economic conditions in a country improve there will be a rapid increase in holdings of foreign bond investors. This is consistent with the above and with the fact that "a new set of institutional investors (for example, mutual

funds, pension funds, and insurance companies) began to invest in emerging market securities in the mid-1990's as the credit ratings of a growing number of emerging markets reached "investment grade" levels (Baa for Moody's and BBB- for Standard and Poor's). However, as the credit ratings of a number of emerging market economies declined below investment grade from July 1997, these new institutional investors either sharply reduced their purchases of emerging markets securities or eliminated their holdings. As a result, the proprietary trading desks of commercial and investment banks and hedge funds became the dominant institutional investors in emerging market securities. The reduction in new issuance activity... following the Russian debt moratorium reflected, to an important degree, the efforts of even these "investors of last resort" to scale back their holdings of emerging market instruments."[11]

Our theory predicts that *foreign* equity flows will also tend to be positively associated with domestic stock returns. Evidence for this is provided in Bohn and Tesar (1998) and Brennan and Cao (1997): more recently Froot *et al.* (1998) present additional, high frequency, data confirming that equity flows and market returns move together;[12] Choe, Kho and Stulz (1998) find that foreign purchases of Korean equities are strongly associated with lagged returns, although somewhat less so during the period of Korea's economic crisis, and Karolyi (1999) reports that foreign purchases of Japanese equities are positively related to current and lagged market returns at a weekly frequency; Timmerman and Blake (1999) analyze monthly portfolio allocations of UK pension funds, and find that changes in the foreign country portfolio allocations of almost all funds have significant positive coefficients on the foreign market returns, which is "consistent with Brennan and Cao's (1997) findings;" finally, recent flows into US overseas mutual funds also appear to be consistent with the theory.[13]

The theory is predicated on the assumption that foreign investors are less well informed than locals about the domestic market.[14] While it is difficult to obtain direct confirmatory evidence for this hypothesis, there is growing

[11]IMF (1999), Chap. II.

[12]Interestingly, they reject the Brennan-Cao hypothesis that this is due to informational asymmetries, attributing it instead to (unexplained) "trend-following" behavior by foreign investors which of course must be matched by "contrarian" behavior on the part of domestic residents.

[13]"Following the devaluation of the Thai baht at the beginning of the third quarter (of 1997), substantial redemptions (2.5 billion) from Asian funds began...Finally, in the fourth quarter, following the events in Hong Kong SAR there were large redemptions across all types of emerging markets funds." (IMF, 1998, pp. 32–33). More recently, a large US distributor of mutual funds noted that declining flows into international mutual funds were due to the fact that "People are reacting to the severe underperformance of international funds relative to the US in the last four or five years, and particularly last year." (*Financial Times*, June 9, 1999).

indirect evidence. For example, Frankel and Schmukler (1996) find that changes in the Net Asset Values of Mexican closed end funds Granger cause changes in the fund prices on the NYSE at times of crisis — the implication is that prices of the underlying shares are set by better-informed locals. Stulz (1997) reports that capital outflows from the residents of Mexico took place following the Colosio assasination in March 1994 while foreign investors were net purchasers of Mexican equities even in December, immediately before the crisis. Klibanoff *et al.* (1998) report that price changes of closed end country funds in the US are strongly influenced by news stories in the *New York Times* even after adjusting for the concurrent change in the Net Asset Value. Kang and Stulz (1997) report that foreign equity investors in Korea concentrate their investments in the larger firms and conclude that their findings are consistent with a model in which foreign investors know more about large firms than about small firms in the markets in which they invest. Portes and Rey (1999) find that cross-border equity flows are well-explained by such informational variables as telephone call traffic and multinational bank branches. Some authorities have suggested that foreign investors are inclined to rely too much on credit ratings and too little on their own research.[15] And concerns have been expressed that the rating agencies were slow in adjusting their ratings to the new realities in Asia;[16] this is consistent with the ratings agencies themselves suffering from an informational disadvantage.

In the following section we shall develop a model which relates debt and equity capital flows to market returns in a setting in which foreign investors are less well informed than domestic investors.

3. A Model of Debt and Equity Capital Flows

3.1. *The basic model*

To simplify, we shall consider a setting in which there is a single risky asset which corresponds to the domestic market portfolio.[17] The market portfolio

[14]Stulz (1997) cites a somewhat different argument of Shleifer and Vishny (1997) which predicts that clients of managers committed to foreign markets will withdraw funds when the returns are poor.

[15]"Several times during 1997 the IIF (*International Institute of Finance%*) urged lenders and investors to undertake thorough research and not to rely on credit ratings", said William R. Rhodes, vice-chairman of the IIF. "Subsequent events showed that those concerns were correct". *International Institute of Finance* press release, January 29, 1998.

[16]"The (credit) ratings agencies were clearly late in downgrading the affected Asian countries" (IMF, 1998, p. 52)

is to be thought of as representing all of the financial wealth of the country. Following Hellwig (1980) and Brennan and Cao (1996), there is assumed to be a continuum of investors, each indexed by i where $i\varepsilon[0,1]$. At time 0 each investor is endowed with x_i units of the market portfolio. The numeraire currency is taken to be the foreign currency which we shall refer to as the "dollar"; without loss of generality the riskless interest rate in dollars is taken as zero.

The domestic market portfolio has a value at time 1 which we denote by $\tilde{u}$, where $\tilde{u}$ is normally distributed with mean $\bar{u}$ and precision h. The *per capita* number of units of the domestic market portfolio, $\tilde{x}$, is normally distributed with mean $\bar{x}$ and precision p. Before trading at time 0, each investor receives a private signal about the future value of the market portfolio:

$$\tilde{z}_i = \tilde{u} + \tilde{\varepsilon}_i \tag{1}$$

where $\tilde{\varepsilon}_i$ is normally and independently distributed with mean 0 and precision s^i.[18] Each investor, without regard to nationality, is assumed to have a negative exponential utility function defined over time 1 wealth,[19] $U(w_i) = -\exp(-w_i/r_i)$, where the risk tolerance, r_i, is assumed to be uniformly bounded.

Information about the time 1 payoff on the domestic market portfolio, $\tilde{u}$, is assumed to be made available gradually by a series of public signals $\tilde{y}_t = \tilde{u} + \tilde{\eta}_t$ at time $\tau_t, t = 1, \ldots, T-1$, where $\tilde{\eta}_t$ is independently and normally distributed with mean 0, and precision n_t. After each signal the market opens for trading and, at time 1, the return of the risky asset is realized and consumption occurs.

Let P_t denote the market value of the market portfolio at time τ_t.[20] In a rational expectations equilibrium investors realize that at time τ_t the previous and current values of the market portfolio, P_j, $j = 0, 1, \ldots, t$, reflect the information held by other investors, and their conjectures about the relation of the price and investors' information are self-fulfilling. The optimal number of units of the market portfolio to be demanded by investor i, $\tilde{D}_{it}$, is $\tilde{\mathfrak{I}}_{it}$ measurable, where $\tilde{\mathfrak{I}}_t$ denotes the subsigma field generated by $\{\tilde{z}_i, \tilde{y}_j, \tilde{P}_j, j = 0, 1, \ldots, t\}$. The

[17]See Brennan and Cao (1997) for a generalization of this model to n risky assets.

[18]Note that we are assuming that investor signal errors are independent. If signal errors are correlated, the equilibrium is qualitatively similar to that described below, except that the coefficients of the linear pricing function in Eq. (2) must be derived from the roots of a cubic equation [see Grundy and McNicholls (1989)]; the simplification made here permits direct calculation of these coefficients.

[19]Note that we are implicitly considering only that portion of the investor's wealth that comes from the domestic market portfolio; we are also implicitly assuming that there are no differences in the consumption tastes of domestic and foreign investors.

[20]For simplicity we assume that the market portfolio pays no dividends between time 0 and time 1.

subsigma field generated by $\{\tilde{y}_j, \tilde{P}_j, j = 0, 1, \ldots, t\}$ is denoted by $\tilde{\mathfrak{I}}_t$. The optimal asset demands and equilibrium market value process are then given in the following theorem:

Theorem 1 (Brennan and Cao (1996)): *In an economy with T trading sessions, there exists a partially revealing rational expectations equilibrium in which prices and asset demands are given by:*

$$\tilde{P}_t = K_t^{-1}\left[(K_t - s)\tilde{\mu}_t + s\tilde{u} - \tilde{x}/r\right] \tag{2}$$

$$\tilde{D}_{ti} = r_i\left[s_i\tilde{z}_i - s\tilde{u} + \tilde{x}/r - (s_i - s)\tilde{P}_t\right] \tag{3}$$

where

$$\tilde{\mu}_t \equiv E(\tilde{u} \mid \tilde{\mathfrak{I}}_t) = \frac{h\bar{u} + \sum_{j=0}^{t} n_j\tilde{y}_j + r^2s^2p\tilde{q}}{h + \sum_{j=0}^{t} n_j + r^2s^2p}$$

$$\tilde{q} = \tilde{u} - (\tilde{x} - \bar{x})/rs$$

$$K_t = h + s + \sum_{j=0}^{t} n_j + r^2s^2p$$

$$r \equiv \int_0^1 r_i\,di, \quad s \equiv \frac{1}{r}\int_0^1 r_i s_i\,di.$$

Theorem 1 shows how $\tilde{P}_t$, the value of the market portfolio, and $\tilde{D}_{ti}$, the number of units in the market portfolio held by investors with different information, are established. Now consider the implications of increasing the frequency of trading: Brennan and Cao (1996) establish that so long as the information flow is sufficiently smooth, the variance of price changes between trading sessions tends to zero as the number of trading sessions is increased without limit. In the limit, as trading becomes continuous, it is possible to price claims whose payoff is contingent on the value of the market portfolio by Black-Scholes (1973) principles, and the wealth allocation converges in probability to a set of quadratic functions of $\tilde{u}$ which is Pareto efficient. Then, as shown in the following Lemma, the prices of all securities are as if there existed a single representative investor with average beliefs and risk tolerance:

Lemma 1 (Brennan-Kraus (1978), Rubinstein (1974)): *As the limiting economy is Pareto efficient, it follows from the results of Brennan and Kraus* (1978) *and Rubinstein* (1974) *that, in the limiting economy, prices are as if there existed a single*

representative investor with risk tolerance r, *and beliefs* $N(\mu_R, K_0^{-1})$, *where* $\mu_R \equiv K_0^{-1}[h\bar{u} + (s + r^2 s^2 p)\tilde{u} - rsp\tilde{x}]$.

Then, given that in the limiting economy prices are supported by a representative investor with constant absolute risk aversion, and that from his perspective the return on the market portfolio is normally distributed with parameters $N(\mu_R, K_0^{-1})$, it follows from the results of Brennan (1979) that all contingent claims on the market portfolio are priced in accord with Black-Scholes (1973) principles; that is, as though the return on the domestic market portfolio were normally distributed with mean P_0, and variance K_0^{-1} where P_0 is the price of the market portfolio at time 0, and $K_0^{-1} \equiv \mathrm{Var}(\tilde{u} \mid \mathfrak{I}_0)$ is the conditional variance of the market return. For example, the price at time 0, of a call option on the market portfolio which expires at time 1 with an exercise price, E, $C(E, 1; P_0, 0)$ is given by:

$$C(E, 1; P_0, 0) = (P_0 - E)N\left(\frac{P_0 - E}{\sigma}\right) + \sigma n\left(\frac{E - P_0}{\sigma}\right) \tag{4}$$

where $n(\cdot)$ and $N(\cdot)$ are the standard normal density and standard normal distribution functions respectively, and $\sigma \equiv \sqrt{1/K_0}$. More generally, the price at time τ when the value of the domestic market portfolio is P, of a call option on the market portfolio with exercise price E, exercisable at time T is

$$C(E, T; P, \tau) = (P - E)N\left(\frac{P - E}{\sigma(\tau, T)}\right) + \sigma(\tau, T)n\left(\frac{E - P}{\sigma(\tau, T)}\right) \tag{5}$$

where $\sigma(\tau, T) = \sqrt{K_0^{-1} - K_T^{-1}}$.

3.2. *Debt contracts*

Debt contracts owned by foreigners range from claims guaranteed by the government, to corporate bonds, and the debts of domestic banks and other financial intermediaries. The ability of debtors to make good on these claims will depend on the level of tax receipts in the case of government, on the market value of the firm in the case of corporate debt, and on the value of their asset portfolio in the case of banks. In each case, there will be a strong relation between the ability of the debtor to make good on his debts and the level of domestic economic activity; it is this common dependence of the quality of a country's debt obligations which gives rise to the notion of "country risk". In order to capture the notion of country risk in a tractable fashion we shall assume that there are dollar denominated risky bonds, all of which are secured

by the domestic market portfolio. Then the payoff on a risky bond which matures at time T with face value, F, and is secured by a fraction k of the domestic market portfolio is given by.

$$\min[kP_T, F] = k\min[P_T, F/k] = k(P_T - \max[P_T - F/k, 0]). \tag{6}$$

Ignoring any intermediate coupon payments, the bond is equivalent to a portfolio consisting of a fraction k of the domestic market portfolio and a short position in k call options on the portfolio with exercise price F/k. Therefore the value of the bond at time $\tau < T$, which we denote by $B(F, k, T; P, \tau)$, can be written as:

$$B(F,k,T;P,\tau) = kP - kC(F/k,T;P,\tau). \tag{7}$$

Define the bond's sensitivity to the value of the market portfolio, or its "delta", by $\delta(F,k,T;P,\tau) \equiv \partial B(F,k,T;P,\tau)/\partial P$. Then

$$\delta(F,k,T;P,\tau) = k\left[1 - N\left(\frac{P - F/k}{\sigma(\tau,T)}\right)\right]. \tag{8}$$

Note that $k > \delta(F, k, T; P, \tau) > 0$: bond values are increasing in the value of the market portfolio since their payoffs are (weakly) increasing in the value of the portfolio at maturity. Similarly, define the bond's "gamma" or rate of change of the bond's delta with respect to changes in the value of the market portfolio, as $\Gamma(F,k,T;P,\tau) \equiv \partial^2 B(F,k,T;P,\tau)/\partial P^2$. Then, differentiating expression (8) with respect to P:

$$\Gamma(F,k,T;P,\tau) = -\frac{k}{\sigma(\tau,T)} n\left(\frac{P - F/k}{\sigma(\tau,T)}\right). \tag{9}$$

Note that $\Gamma < 0$, so that a bond's delta is a monotonic decreasing function of the value of the market portfolio: as the value of the market portfolio increases, the risk of the bond decreases, and therefore its value becomes less sensitive to changes in the value of the market portfolio.

Since $\delta \neq 0$, it is possible in the limiting economy to replicate the returns on an equity portfolio by continuous trading in a single bond or portfolio of bonds and the riskless asset. Formally:

Lemma 2 *The wealth outcome of individual i in the limiting economy that is generated by following the strategy of holding D_{ti} units of the market portfolio at time t and $W_i - D_{ti}P_t$ dollars in the riskless asset, may be replicated by holding b_{tij} units of bond $j (j = 1, \ldots, J)$ at time t and $W_i - \sum_{j=1}^{J} b_{tij}B_{jt}$ dollars in the riskless asset, where B_{jt} denotes the price of bond j at time t and b_{tij} is chosen so that $\sum_{j=1}^{J} b_{tij}\delta_{tj} = D_{ti}$.*

This replication result means that the equilibrium described in Theorem 1 may be extended in the limiting economy to allow trading in risky bonds.

Theorem 2 *In the limiting economy in which risky debt contracts are traded, the value of the domestic market portfolio is given by* (2), *the price of debt contracts is given by Eq.* (7) *and portfolio holdings satisfy:*

$$\tilde{y}_{ti} + \sum_{j=1}^{J} \tilde{b}_{tij}\delta_{tj} = \tilde{D}_{ti} = r_i\left[s_i\tilde{z}_i - s\tilde{u} + \tilde{x}/r - (s_i - s)\tilde{P}_t\right] \tag{10}$$

$$\sum_{i\in[0,1]} \tilde{b}_{tij} = 0, \quad \text{for } t \in [0,1],\ j = 1,\ldots, J \tag{11}$$

where $\tilde{y}_{ti}$ *is the number of units of the market portfolio, and* $\tilde{b}_{tij}$ *is the number of units of bond* j *held by individual* i *at time* t.

The theorem says that the final wealth allocation is the same whether investors hold $\tilde{D}_{ti}$ units of stock, or whether they hold some other number of units of stock but achieve the same exposure to the market portfolio, or "portfolio delta", by holding bonds. In either case the investor's instantaneous change in wealth is given by $\tilde{D}_{ti}\,dP$. Note that the individual values of the bond holdings, $\tilde{b}_{tij}$, are indeterminate without further restrictions, but the aggregate supply of bonds is zero.

Agents are often prohibited from holding equity directly. For example, most economies have at various times restricted the equity holdings of foreigners, and many developing economies continue to do so. The restrictions may also result from foreign regulations for particular classes of agent; for example, banks are often prohibited from holding equity directly. As a result, if they wish to achieve exposure to a particular market they must do so by making loans or buying bonds that are exposed to the risk of that market. We wish to compare the trading strategies of agents who buy only equity, or shares of the market portfolio, with the strategies of investors who invest in risky fixed income instruments.

Consider a class of agents denoted C, who, perhaps because of portfolio constraints or because they are foreigners, are prevented from buying shares of the market portfolio directly. To simplify, we shall assume that each investor $i \varepsilon C$ invests in a single debt contract, j. Then the investor's optimal holding in debt contract j is

$$b_{tij} = r_i\left[s_i\tilde{z}_i - s\tilde{u} + \tilde{x}/r - (s_i - s)\tilde{P}_t\right]/\delta_{tj} \equiv D_{ti}/\delta_{tj} \tag{12}$$

and the value of his bondholdings is $b_{tij}B_{tj}$.

Now consider the proportional rate of change in the number of bonds of type j held by the investor with respect to a change in the level of the domestic market portfolio, ε_{bit}, which we refer to as the investor's "personal bond elasticity":

$$\varepsilon_{ijt} \equiv \frac{1}{b_{tij}} \frac{\partial b_{tij}}{\partial P} = \frac{1}{D_{ti}} \frac{\partial D_{ti}}{\partial P} - \frac{1}{\delta_{tj}} \frac{\partial \delta_{tj}}{\partial P}. \tag{13}$$

Define $\eta_t \equiv \frac{1}{D_{ti}} \frac{\partial D_{ti}}{\partial P}$, as the semi-elasticity of the holdings of a pure equity investor with respect to the level of the market index; we shall call this the investor' s "personal equity elasticity". Define $\gamma_{jt} \equiv \frac{1}{\partial_{tj}} \frac{\partial \delta_{tj}}{\partial P} = \frac{\Gamma_{tj}}{\delta_{tj}}$ as the semi-elasticity of the delta of the bond with respect to the level of the market index; we shall call this the bond's "delta elasticity". A positive personal equity elasticity means that an investor increases the number of shares that he holds in the market portfolio as the value of the portfolio rises. Since a bond's delta is always positive and its gamma is always negative, it follows that a bond's delta elasticity is always negative. Notice that the personal equity elasticity depends on the identity of the investor, while the bond's delta elasticity depends only on the characteristics of the bond. Then the investor's personal bond elasticity may be written as the difference between the investor's personal equity elasticity and the bond's delta elasticity:

$$\varepsilon_{ijt} \equiv \eta_{it} - \gamma_{jt} \tag{14}$$

and we have the following result:

Proposition 1

(i) *An investor's personal bond elasticity is equal to the difference between the investor's personal equity elasticity and the bond's delta elasticity.*

(ii) *Since a bond's delta elasticity is always negative, an investor's bond elasticity is always greater than his personal equity elasticity.*

Note that it is possible that the absolute value of an investor's personal bond elasticity may be less than the absolute value of his personal equity elasticity. In this case the volatility of an investor's holdings in foreign equities will be greater than the volatility of his holdings in the bond if he is forced to replicate his desired equity payoff with a dynamic strategy in bonds. This can only happen if the investor's personal equity elasticity is negative. Therefore, in order to use the results of Proposition 2 to make claims about the volatility of international flows of debt and equity capital, it is necessary for us to make an assumption about the relative information of domestic and foreign

investors. The assumption that we shall make is that foreign investors are less well informed than the average investor (and therefore less well informed than the average domestic investor) about the payoff on the domestic market portfolio.[21] Formally:

Assumption A: For any foreign investor, i,

$$s_i < s.$$

The assumption implies that foreign investors start the period with less precise signals about the payoff on the domestic portfolio, and therefore receive more information from the subsequent public signals.[22] Assumption A then implies the following results:

Proposition 2

(i) *The personal equity elasticity of foreign investors is positive.*
(ii) *A foreign investor's personal bond elasticity exceeds his personal equity elasticity.*
(iii) *A foreign investor who is long the domestic market* ($\tilde{D}_{it} > 0$), *and is constrained to holding bonds, will turn over his portfolio at a higher rate than if he were holding a pure equity portfolio.*
(iv) *The total volume of asset sales by foreigners when the domestic market declines is higher if they are constrained to holding bonds than if they make equity investments.*

Thus, it is holdings of debt that are likely to constitute "hot money" in the sense that they are proportionately more sensitive to domestic market returns than are equity holdings.

The following lemma describes the determinants of a bond's delta elasticity:

Lemma 3

(i) γ_{jt}, *the delta elasticity of bond* j *at time* t, *is given by*

$$\gamma_{jt} = -\frac{h(x_{jt})}{\sigma_t} \tag{15}$$

where $x_{jt} = (P - F_j/k_j)/\sigma_t$, $\sigma_t = \sigma(t, T_j)$, *and* $h(x)$ *is the hazard function of the standard normal density function.*

[21]This is consistent with the pleas of the Group of 7 for greater "transparency" in international markets. It is also consistent with the evidence of Brennan and Cao (1997) on foreign equity flows to emerging markets.

[22]Foreign investors suffer from what Brennan and Cao (1997) refer to as a "cumulative information disadvantage".

Since the hazard function of the normal distribution is increasing,

(ii) *a bond's delta elasticity, γ, is decreasing in P, the value of the market portfolio, and in k, the fraction of the portfolio that collateralizes the bond.*

(iii) *for $P \geq F_j/k_j$ a bond's delta elasticity, γ is increasing in $\sigma(t,T) \equiv (T-t)^{\frac{1}{2}}\sigma$, and is therefore increasing in both the risk of the economy, σ, and in the time to maturity of the bond, $(T-t)$; for $P \ll F_j/k_j$ a bond's delta elasticity, γ, is decreasing in $\sigma(t,T) \equiv (T-t)^{\frac{1}{2}}\sigma$, and is therefore decreasing in both the risk of the economy, σ, and in the time to maturity of the bond, $(T-t)$.*

Lemma 3 implies that the bond's delta elasticity is increasing in $\gamma(t, T)$ if the bond's face value exceeds the value of the collateral. This implies the following for the personal bond elasticity of a foreign investor:

Lemma 4

(i) *A foreign investor's personal bond elasticity is decreasing in the term to maturity of the bond for $P \geq F_j/k_j$.*

(ii) *A foreign investor's personal bond elasticity is increasing in the term to maturity of the bond for $P \ll F_j/k_j$.*

Lemmas 3 and 4 imply that the most volatile bond holdings will be those of bonds which are well collateralized, and that for well collateralized bonds those with the shortest maturities will be the most volatile. Thus, consistent with the popular view, the hottest money is that which is invested in relatively riskless short term bank deposits.

The major empirical implication of our theory that we shall examine in Sec. 5 below is that foreign debt and equity flows are positively related to the return on the market portfolio. While the theory implies that foreign debt holdings are proportionately more sensitive to market returns that are foreign equity holdings, lacking reliable data on the market values of asset holdings, we shall restrict our attention to the foriegn portfolio investment flows to three countries affected by the Asian crisis. However, before turning our attention to the data, we consider an illustrative example of the model.

4. Illustrative Example

To illustrate the model we consider a simple example in which the (risk-tolerance-weighted) average precision of foreign investors, s_F, is less than that of the average investor. Define F as the set of foreign investors, and define the aggregate share-equivalent holdings of foreign investors, $\widetilde{D}_{tF}$, by $\widetilde{D}_{tF} \equiv \int_{i\in F} D_{ti}di$. Then, using Eq. (3) and noting that $\int_{i\in F}\tilde{z}_i = \tilde{u}$ a.s., it follows that the aggregate share-equivalent holdings of foreign investors may be written as:

$$D_{tF} = \tau_F\left[(s_F - s)\tilde{u} + \frac{\tilde{x}}{\tau}\right] - \tau_F(s_F - s)\tilde{P}_t \tag{16}$$

where the foreign investor risk tolerance and signal precision are given by $\tau_F \equiv \int_{i\in F} \tau_i di$, and $s_F \equiv \frac{1}{\tau_F}\int_{i\in F} \tau_i s_i di$ respectively. Note that, under the assumption that foreign investors are less well informed, $s_F < s$ so that the aggregate share-equivalent holdings are an increasing linear function of the domestic market level. The coefficient relating foreign investor holdings to the market level is given by the product of the foreign investor risk tolerance, τ_F, and the foreign investor information disadvantage $(s - s_F)$. The first term in expression (16) depends *inter alia* on the aggregate risk tolerance of foreign investors, τ_F, relative to that of the market as a whole. It is in the nature of a scaling proportion. Similarly, the coefficient of $\tilde{P}_t$ depends on how the price index is scaled as well as the foreign investors' risk tolerance and information disadvantage. For our numerical example, we take the share-equivalent demand of foreign investors to be:

$$\widetilde{D_{tF}} = 100 + \tilde{P}_t. \tag{17}$$

We suppose that foreigners either invest in shares, in which case they hold $\widetilde{D_{tF}}$ shares, or are constrained to invest in bonds of type j, in which case they hold the risk-equivalent number of bonds, $b_{tF} = \widetilde{D_{tF}}\delta_t$ bonds. The bonds are assumed to have a face value, F, of 200 and to be secured by a fraction, k, of the value of the scaled market portfolio which is equal to 2; thus the bonds will be paid in full provided that the scaled market portfolio or market index exceeds 100. We take the standard deviation of the market return $\delta \equiv \sqrt{1/K_0}$ to be 30. Then the proportional volatility of the market index at the default point is 30 percent, and declines to 20 percent when the index level is 150 and the asset coverage of the bond is 1.5. Equation (17) implies that foreign investors reduce their holdings by 0.5 percent for a 1 percent drop in the market index when the market index is at 100 and the elasticity of foreign equity holdings increases slowly towards unity for higher levels of the market index.

Figure 1 plots as a solid line $\widetilde{D_{tF}}$, the number of shares that a foreign investor would hold as a function of the level of the market index as calculated from Eq. (17). This increases slightly with the level of the index reflecting the informational disadvantage of the foreign investor. The figure also shows the *risk-equivalent* number of bonds, b_{tFj}, when the bond maturity, T, is either one year or five years: this is the number of bonds that would be held by the same investor if he were constrained to invest in bonds of either one or five years

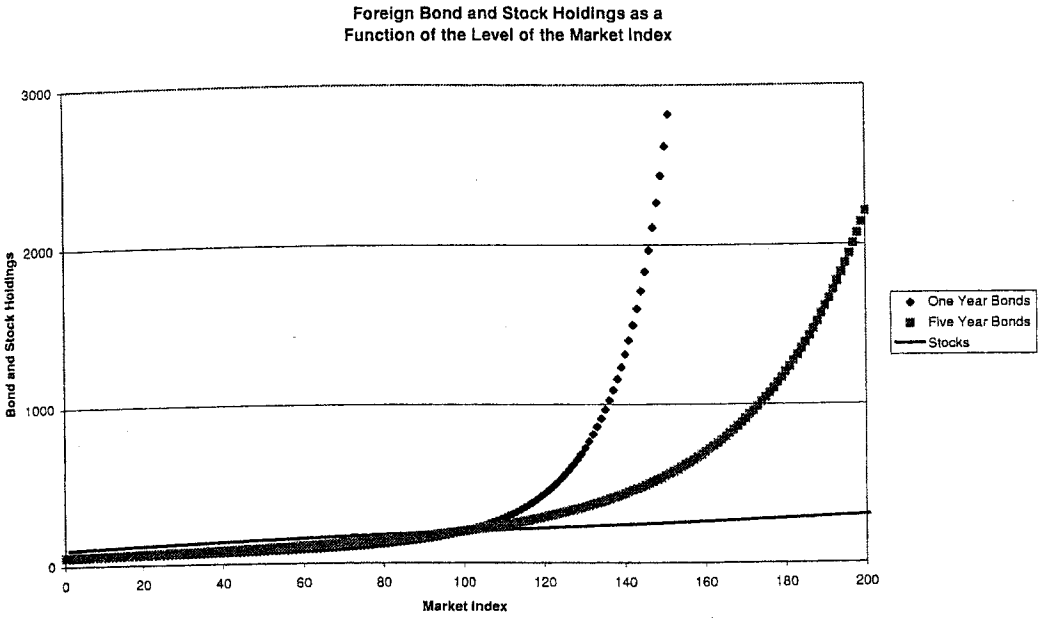

Figure 1. The figures shows the number of shares held by a hypothetical foreign investor as a function of the domestic market index. Also shown are the holdings of one and five year bonds that have the same risk as the given stock position. The face value of the bonds is 200 and they are collateralized by twice the level of the index. The standard deviation of the market return is 30 per year and the interest rate is assumed to be zero.

of maturity instead of stock. The risk-equivalent number of bonds is a convex increasing function of the level of the market index. When the market index is 100 so that both bonds have an asset coverage ratio of one, the desired bondholding for either maturity is 200 units; when the market index is 50 percent higher at 150, so that the coverage ratio is 1.5, the desired bondholding is 548.2 bonds for five-year maturity and 2615.6 *bonds for the one-year maturity!* Conversely, if the market index drops from 150 to 100, under these assumptions foreign bondholders will liquidate 93 percent of their one-year bondholding, but only 64 percent of their five-year bondholding, and 20 percent of their stockholdings. Even if the market drops only by 10 percent from 150, the stockholding drops by 6.0 percent, the five-year bondholding by 28.9 percent, and the one-year bondholding by 85.1 percent.

This example illustrates in a dramatic fashion that foreign debt holdings of risk averse expected utility maximising investors are likely to be much more volatile than foreign equity holdings, and that the most volatile holdings are likely to be represented by short-term debt contracts. Foreign investors will

be willing to hold very large quantities of these contracts when the risk of default is low, but will scale back their holdings as default risks rise. In this model what makes hot money hot is the type of contract that is held and the way in which the risk of the contract changes as the economic fortunes of the host country change. Consistent with popular intuition, the hottest money is that which is held in short term contracts which are effectively collateralized by the domestic market portfolio. In the next section we shall see the extent to which capital flows to three Asian countries were associated with returns on the domestic market portfolio.

5. Capital Flows to Three Asian Countries

We illustrate the main predictions of the theory, that international flows of capital, whether equity or debt, will depend on the return on the domestic portfolio and that debt flows will be more volatile than equity flows, by reference to capital flows to Indonesia, Korea, and Thailand, three countries that were strongly affected by the Asian financial crisis.

Figure 2 plots the cumulative flows of foreign debt, equity and bank loan capital to Indonesia, Korea, and Thailand on a quarterly basis from 1995.1 to 1998.2. Also shown on each chart is the (scaled) level of the local stock market index in dollars.[23] For all three countries there is a very pronounced tendency for the cumulative flows of *bank loans* (solid lines) to decrease along with the stock market level (dotted lines), although for Korea the turndown in the cumulative flow lagged the market decline. For *equity capital* (light column) the cumulative flow to Indonesia turned down sharply and became negative as the stock market fell, while in Korea the cumulative flow stopped increasing but did not fall as the stock market fell.[24] In Thailand, the cumulative flow of equity capital stopped increasing but did not fall in the third quarter of 1997, about a year after the stock market turned down. Cumulative flows of *debt capital* peaked in Korea and Thailand in the fourth quarter of 1996, a couple of quarters after the markets turned down decisively. In Indonesia, in contrast, net flows of private debt capital remained positive or close to zero

[23]The capital flows are in $m and are taken from the *International Financial Statistics* published by the IMF. The stock market indices are computed from the International Finance Corporation total return series in US dollars, ignoring dividend payments.

[24]Indonesia relaxed controls on foreign equity inflows in September 1997; Korea progressively raised the limits on foreign equity holdings throughout 1997. (IMF, *Exchange Arrangements and Exchange Restrictions*, Washington, DC, various editions.)

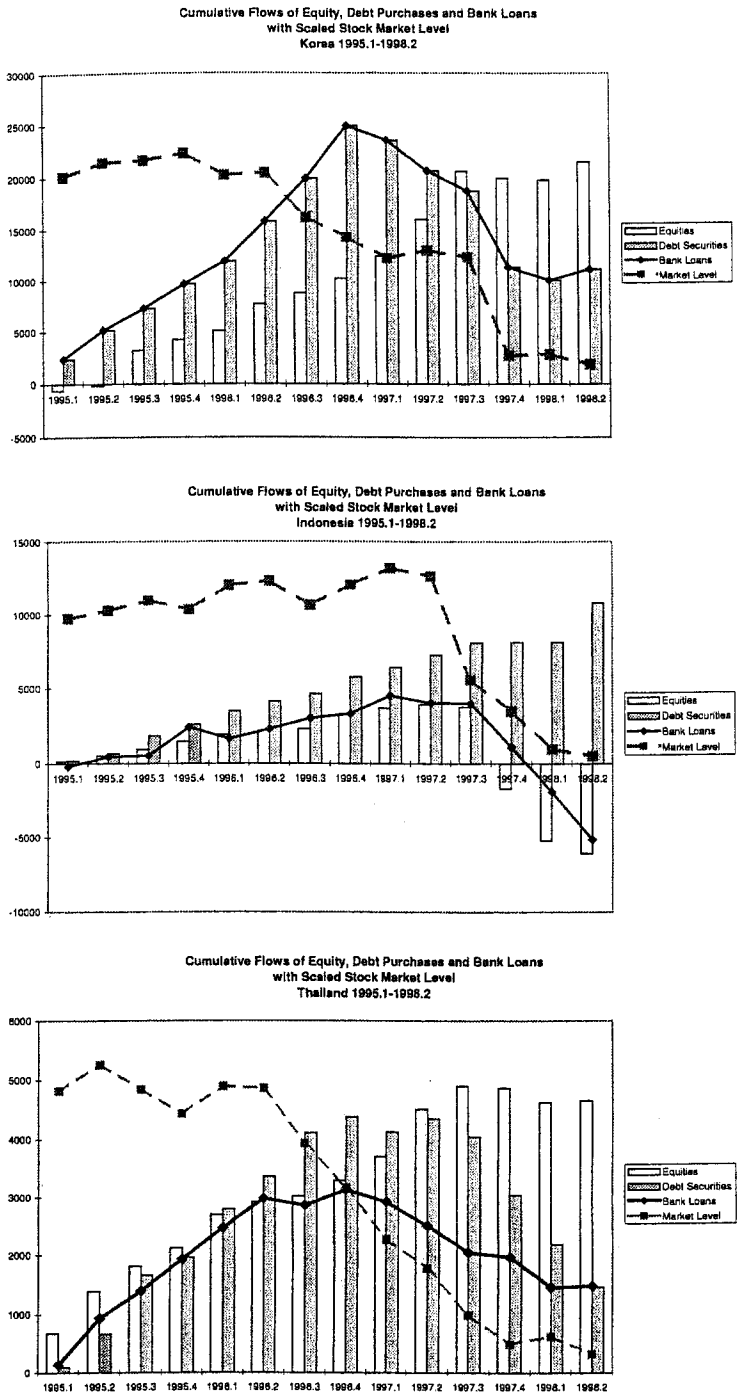

Figure 2. Cumulative Capital Flows and the Level of the Stock Market

The figures show the cumulative flows in USD million from 1995.1 of debt and equity securities and bank loans into Korea, Indonesia and Thailand, taken from *International Financial Statistics*. The dotted line represents the rescaled level of the domestic market index in USD calculated by compounding the returns from the International Finance Corporation (IFC) total dollar return series.

Table 3. Quarterly Capital Flows and Stock Market Returns 1995.1–1998.2

Dependent Variable	Constant	R_{mt}	R_{mt-1}	$(1+R_{mt})(1+R_{mt-1})$	R^2 Nobs	F-stat (p-value)
			Indonesia			
Equity	144.1	4380.5			0.43	10.62**
	(0.36)	(3.26)			14	(0.01)
	191.3	2492.5	3036.4		0.50	6.93**
	(0.46)	(1.44)	(1.66)		13	(0.01)
	−3296.1			3446.5	0.52	13.93**
	(3.95)			(3.73)	13	(0.00)
Debt	777.6	27.22			0.00	0.97
(including	(3.81)	(0.04)			14	(0.96)
1998.2)	803.07	958.6	−1405.7		0.04	1.23
	(3.95)	(1.12)	(1.56)		13	(0.33)
	964.3			−178.9	−0.08	0.13
	(2.16)			(0.36)	13	(0.72)
Debt	710.0	783.1			0.26	5.28*
(Excluding	(7.30)	(2.30)			13	(0.04)
1998.2)	758.7	503.5	718.8		0.41	4.78*
	(8.47)	(1.32)	(1.40)		12	(0.04)
	72.0			676.5	0.39	7.98*
	(0.32)			(2.83)	12	(0.02)
Bank	147.0	3894.8			0.43	10.72**
Loans	(0.41)	(3.27)			14	(0.01)
	262.6	1057.2	4648.3		0.78	22.08**
	(1.08)	(1.03)	(4.30)		13	(0.00)
	−3172.0			3418.4	0.66	24.78**
	(5.11)			(4.98)	13	(0.00)
			Korea			
Equity	1653.5	4446.0			0.50	13.81**
	(5.58)	(3.72)			14	(0.00)
	1615.0	4053.1	-952.3		0.51	7.22**
	(4.88)	(3.43)	(0.78)		13	(0.01)
	28.76			1560.3	0.30	1.32
	(0.03)			(1.15)	13	(0.27)
Debt	1739.3	7755.7			0.20	4.29
	(1.88)	(2.07)			14	(0.06)
	2153.3	8973.4	4126.9		0.22	2.69
	(1.95)	(2.27)	(1.01)		13	(0.12)
	−4499.2			6640.9	0.21	4.23
	(1.69)			(2.06)	13	(0.06)

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	(1.69)			(2.06)	13	(0.06)

Table 3 reports the results of regression of the three components of quarterly capital flows on the domestic market returns for the three countries. Consistent with the results of Brennan and Cao (1997), and with the hypothesis that foreigners are less well informed about the domestic market than are domestic residents, the correlation between each component of the capital flows and domestic market returns is positive for all three countries (with the single exception of equity flows to Thailand where the correlation is negative, but insignificant) and, despite the small sample size, the simple regression relation is significant at the five percent level for equity, debt, and bank loan flows to Indonesia and bank loan flows to Korea. We note also that, except for Indonesia, the estimated sensitivity to market returns is much greater for bank loans and debt flows than it is for equity flows.

Our theoretical model assumes that all agents respond immediately to new information. In reality, it may take some time for foreign investors to react to news about the domestic economy. To allow for this possibility the regressions were repeated including both the current and lagged value of the domestic market return; since this reduces the already small number of degrees of freedom, we also repeated the regression with a single independent variable, the compound market return over the current and past quarter. We note first that for each of the three types of capital flow, for each of the three countries (again with the sole exception of equity flows to Thailand), the coefficients on the market returns are positive, consistent with the theory. Restricting attention to the compound market return regressions, the bank loan flow regression is significant at better than the one percent level in every case and the regression exlains 59–66 percent of the variance. The debt flow regression is highly significant for Thailand where it explains 62 percent of the variance; it is also significant for Indonesia, but not significant for Korea; this may be because Korea maintained restrictions on foreign purchases of Korean bonds until December 1997. Finally, the equity flow regressions are highly significant for Indonesia and Korea where they explain 52 percent and 30 percent of the variance respectively. However there appears to be no significant relation between foreign equity flows and domestic market returns for Thailand.

Overall, the results are consistent with the model we have developed. Capital flows are strongly influenced by current and lagged domestic market returns and the relation is at least as strong or even stronger for debt flows than it is for equity flows. While the simple theory we have developed emphasizes the contemporaneous relation between flows and returns, we find evidence of a lagged relation.[26] While some authors have been content to describe this

[26]This is not inconsistent with the Brennan-Cao (1996) model which predicts that market returns will be positively auto-correlated so that current flows would be positively related to past as well as current returns.

simply as "trend following behavior",[27] we note that this labelling of the phenomenon offers no explanation why it is *foreigners* rather than domestic agents who exhibit this behavior. We suggest that in equity markets it is due to foreigners being at an informational disadvantage and reacting slowly to new information about the country.[28] The effects of information asymmetry on portfolio flows are compounded in the case of debt flows by the fact that, whereas a foreign investor will typically wish to reduce his exposure to a given country as its market falls, his exposure will actually increase if he holds an unchanged position in debt contracts.

6. Conclusion

In this paper we have shown that if foreigners are less well informed about the domestic market than domestic investors, and there are foreign investors who are constrained to invest in debt securities, then international flows of debt as well as equity capital will depend positively on the returns on the domestic market index, and the elasticity of debt flows with respect to the market index will exceed those of equity flows and will be highest for short term debt flows. Hence we have provided a model in which capital flows that are invested in short term debt securities are likely to constitute "hot money".

We have found that the predictions of the model are supported by the behavior of flows of equity, debt and bank loan capital to three countries affected by the Asian crisis. There is evidence that all three categories of flow are positively related to the domestic market return. We have also found evidence of a lagged relation of flows to returns; its magnitude seems to be too large to be explained by the current model. The challenge is to develop a model with asymmetric information and lagged decision making which will explain such a trend following behavior by foreign investors. Such work is currently in progress.

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[27]See Froot *et al.* (1998).

[28]Slow reaction seems consistent with the notion of investors following a country asset allocation *strategy*, since the connotation of *strategy* is that it is changed infrequently or only after careful deliberation.

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