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Guillermo Felices[(1)] and Bjorn-Erik Orskaug[(2)]

Abstract

This paper studies the determinants of capital flows defined as gross external bond and syndicated loan issuance to a group of emerging market economies (EMEs) since 1992. We follow the previous literature by estimating an explicit disequilibrium demand and supply model of capital flows using maximum likelihood techniques. We use the estimated supply and demand determinants to calculate time-varying probabilities of international supply-side rationing, estimating the model for the asset class as a whole. We then explore applications to individual EMEs including Brazil, Chile, China, Colombia, Korea, Mexico, Poland and Thailand using a longer time period than in previous work. For our selection of EMEs taken together, the main determinants of the supply of capital from the rest of the world are credit ratings, EME spreads, world growth and US high-yield spreads. On the demand side, the EME equity index has a positive effect on capital flows, while EME spreads and commodity prices have a negative one. The applications to individual countries show similar signs. Finally, we calculate the probability of capital crunch for EMEs in aggregate and for some countries individually.

Key words: Capital flows, disequilibrium, emerging markets, rationing.

JEL classification: F320, F340, O190.

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Contents

Summary

This paper studies the determinants of capital flows (defined as gross external bond and syndicated loan issuance) to a group of emerging market economies (EMEs) since 1992. Capital flows to EMEs are of particular interest, because their rapid reversals have been responsible for various financial crises in large economies such as Brazil, Russia, Mexico and several East Asian countries in the past few decades. Understanding the determinants of capital flows is therefore important in order to avoid future financial crises and their potential spillover effects on other financial markets, including developed ones.

For emerging market economies, the cost of financing debt via international markets has traditionally been higher than for developed ones, as investors attach risks to their ability to repay their debt, either in the form of bonds or bank loans. As a result, investors require interest rates that incorporate a premium over 'safe' interest rates in order to compensate them for taking such risk. The combined observation of capital flows and the associated interest rates reflects the interaction of the supply of capital from the rest of the world to EMEs and the demand for capital from EMEs. But this interaction might not reflect an efficient competitive equilibrium resulting from conventional supply and demand analysis. The supply of flows could, for instance, be rationed if creditors are unwilling to lend to a country at a cost of capital that is acceptable for the borrower. This could occur, for example, if creditors have imperfect information about the borrowers' ability or willingness to repay their obligations. Similarly, at times and at a given cost of capital, the demand for flows by debtor countries could be dwarfed by excess supply from the rest of the world. This could occur, for example, if the supply of capital by international investors – perhaps driven by their search for higher returns – outpaces the capital that EMEs require to cover their financing needs.

In order to account for the possibility of disequilibrium in capital flows to EMEs we follow earlier work by Ashoka Mody and Mark Taylor by estimating an explicit disequilibrium demand and supply model of capital flows, where the quantity transacted is the minimum of either demand or supply. We use the estimated supply and demand determinants to calculate time-varying probabilities of international supply-side rationing. Unlike Mody and Taylor's paper, which estimates the model on four countries individually, we estimate it for the asset class as a whole over the period 1994 to 2004. We then explore applications of the model to a few individual EMEs including Brazil, Chile, China, Colombia, Korea, Mexico, Poland and

Thailand using a longer time period than Mody and Taylor (1992 to 2004 instead of 1990 to mid-2000).

For our selection of EMEs taken together, our results suggest that the supply of flows to EMEs is positively related to EME spreads (the difference between borrowing and lending rates – a measure of expected returns), sovereign credit ratings, and estimates of world GDP growth; and negatively related with US high-yield spreads. This is in line with what theory suggests. On the demand side, domestic equity indices have a positive effect on capital flows, while the ratio of reserves over imports and EME spreads (a measure of the cost of capital to borrowers) have a negative one. Again, this is in line with theoretical priors. We find similar results for most countries when using individual country data. Finally, we present the probability of a 'capital crunch' (when the supply of capital is less than demand) for EMEs taken as a whole, and for a specific application to Brazil.

1 Introduction

The analysis of capital flows to emerging market economies (EMEs), both from a short and a long-run perspective has long captured the interest of academic economists and policymakers.[1] The resurgence of capital flows to EMEs in the first half of the 1990s subsequently led to a period of high volatility, with periods of seeming exuberance interrupted by periods of financial crises that affected large emerging economies such as Mexico, Russia, Brazil and several East Asian countries.[2]

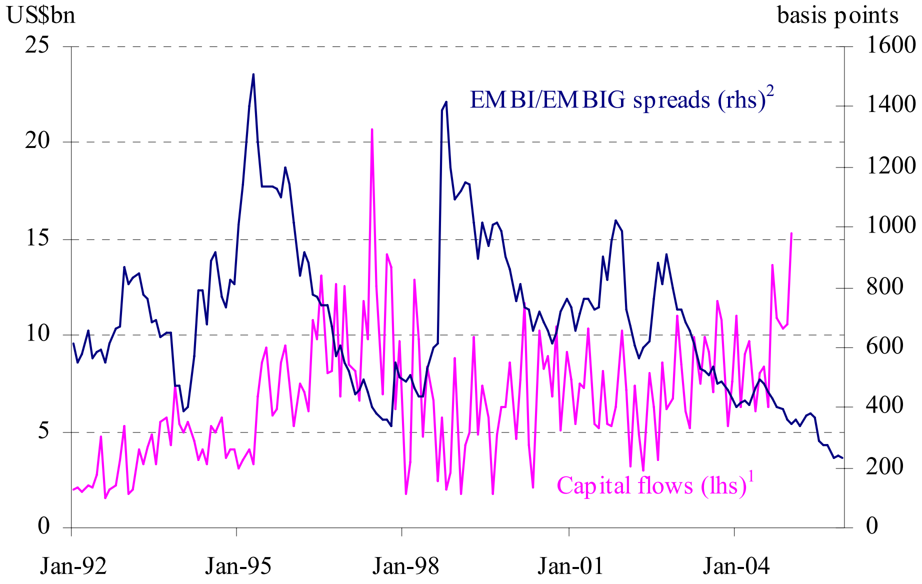
The volatile nature of EME capital markets seems to reflect the fact that new information, right or wrong, about a debtor country's default risk can significantly affect capital flows, leading to a change in the magnitude of flows or even a 'sudden stop' altogether.[3] But other factors, external to an EME debtor, can also disrupt flows. It is important to identify the main determinants of capital flows in order to avoid or minimise the welfare costs of such disruptions. Traditionally, this has been analysed in a so-called 'push and pull' framework as in Agénor (1998), Mody, Taylor and Kim (2001) and Ferrucci, Herzberg, Soussa and Taylor (2004). Push factors refer to global determinants of flows from the world financial markets to EMEs, while pull factors refer to country-specific elements that reflect domestic fundamentals and investment opportunities. Although the 'push-pull' approach is a useful framework to understand flows to EMEs, few studies have implemented a standard supply and demand analysis to study the behaviour of capital flows over time. Unlike the 'push-pull' framework, such analysis has the advantage of allowing the same variables to determine both supply and demand.

Chart 1 shows the volatile behaviour of capital flows to EMEs as well as a measure of the cost of capital these countries has faced (the EMBI/EMBIG spread[4]) since 1992. The combined observation of capital flows and the cost of capital reflects the interaction of the supply of capital from the rest of the world to EMEs and the demand for capital of EMEs. For creditors supplying capital, the interest rate associated with these flows reflects expected returns, defined as the sum of a risk-free rate in US dollars plus a (credit) risk premium. For debtors demanding capital, it represents the cost of funds. But the outcomes observed in Chart 1 might not reflect an efficient competitive equilibrium resulting from the interaction of supply and demand. The

[1] See for example, Eichengreen (2003) and Reinhart and Rogoff (2004) for recent discussions, and Lucas (1990) for a seminal one.
[2] Interesting surveys of these episodes include Calvo, Leiderman and Reinhart (1996), Taylor and Sarno (1997), International Monetary Fund (2000) and Roubini and Setser (2004).
[3] See Calvo and Reinhart (1999) for a discussion of sudden stops and Eichengreen and Mody (1998) for a description of the increasing, but volatile pattern of flows in the 1990s.
[4] The spreads series corresponds to EMBIG spreads from 1998 to 2005. From 1992 to 1997 we concatenate the EMBIG with the EMBI spread by applying the EMBI's growth rate to the EMBIG.

supply of flows could, for instance, be rationed as creditors are unwilling to lend to a country at a cost of capital which is acceptable for the borrower. Similarly, at times and at given cost of capital levels the demand for flows by debtor countries could be dwarfed by excess supply.

Chart 1: Gross capital flows to EMEs and the EMBIG spread



Sources: Dealogic Bond- and Loanware, JP Morgan.
[1] Sum of bond and syndicated loan issuance to Brazil, Chile, China, Colombia, Korea, Mexico, Poland and Thailand.
[2] Monthly changes in EMBI from 1992 to 1998 added to EMBIG.

Previous work by Mody and Taylor (2004) has estimated the determinants of supply and demand for international capital flows to emerging markets using an explicit disequilibrium approach. They conducted the study for four different countries separately for the period of 1990 to mid-2000. Their estimation was carried out using maximum likelihood techniques which allowed them to calculate the probability that the market for flows has been supply (or demand) constrained at different points in time.

The theoretical appeal of the disequilibrium approach is that capital flows might plausibly be relatively unresponsive to interest rate movements. One reason why the cost of credit to EMEs at any given point in time might not clear markets is due to credit rationing as explained in the seminal work of Stiglitz and Weiss (1981). Their main idea is that interest rates might not always clear credit markets because lenders may have incomplete information about borrower's creditworthiness or their level of risk aversion. Under these circumstances they will try to avoid high-risk borrowers even if these are willing to pay very high interest rates. In some instances, therefore, the supply for credit might be below the demand at any given interest rate and there will be a credit crunch.

As in Mody and Taylor (2004), who in turn follow Maddala (1983) and Kiefer (1980), we estimate the disequilibrium supply and demand system using maximum likelihood techniques. The estimated supply and demand equations can then be used to estimate the probability that supply is less than demand at any given point in time, in other words, the probability of a capital crunch.

Unlike Mody and Taylor (2004), who estimate supply and demand functions for four countries separately, this paper estimates the model for EMEs as a whole from 1992:1 to 2004:12 (the period for which an aggregate local equity index is available). We then apply the model to a few countries including Brazil, Chile, China, Colombia, Korea, Mexico, Poland and Thailand, but over a longer time period than Mody and Taylor (1992:1 to 2004:12 instead of 1990:1 to 2000:6). We then use the model to calculate the probability of a capital crunch for EMEs in aggregate. We apply the same technique to assess periods of capital rationing in selected countries.

Our results suggest that the supply of flows to EMEs is positively related to EME spreads (a measure of expected returns), sovereign credit ratings, and estimates of world GDP growth; and negatively related with US high-yield spreads. This is in line with our theoretical priors. On the demand side, domestic equity indices have a positive effect on capital flows, while the ratio of reserves over imports and EME spreads (a measure of the cost of capital to borrowers) have a negative one. Again, this is in line with theoretical priors. We find similar results for most countries when using individual country data. Finally, we present the probability of a capital crunch for EMEs taken as a whole, and for a specific application to Brazil.

The rest of the paper is organised as follows. Section 2 discusses the theoretical causes of a capital crunch. Section 3 presents the empirical model and the econometric technique used to estimate it. Section 4 describes the data. Section 5 presents the identification approach used to deal with the problem of endogeneity. Section 6 discusses a Monte Carlo experiment that lends support to the identification approach outlined in the previous section. Section 7 reports and discusses the results. Section 8 concludes.

2 Theoretical background

Capital markets in EMEs are relatively fragile compared with those in mature markets. Macroeconomic fundamentals, such as a country's debt and inflation profiles, are sometimes weak and subject to sudden change. In addition, capital markets are not as deep as in developed markets, therefore changes in investor sentiment due to evolving fundamentals or external conditions can lead to a reassessment of risk, and hence to rapid movements in asset returns in EMEs. When capital markets are not mature enough they could be more prone to market imperfections that prevent yields – or interest rates – from clearing them.

If interest rates do not clear credit markets at any given point in time, then the observed quantity of credit reflects excess supply or demand. When the market is constrained by the supply of credit it is said to be rationed (Stiglitz and Weiss (1981)). Conversely, when the market is constrained by demand it is said to have excess supply which in the case of capital markets could be associated with times of exuberance.

The basic idea behind rationing is that interest rates might not always clear credit markets when borrowers are willing to pay very high interest rates. Lenders will then assume that projects are too risky. Hence, asymmetric information about the creditworthiness of borrowers is at the root of credit rationing.

There are different ways in which credit rationing is reflected in international financial markets. Mody and Taylor discuss three manifestations of rationing, all of which result from asymmetric information. In all three cases, asymmetric information leads to a risk premium that opens up a wedge between the interest rate under perfect information and the one that prevails when borrower creditworthiness is uncertain. That wedge, however, can be present permanently (as implied by Stiglitz and Weiss); sporadically and then disappear (as in a 'sudden stop' *à la* Calvo and Reinhart (1999)); or it might fluctuate with the cycle (as in the financial accelerator model of Bernanke, Gertler and Gilchrist (1999)).

In the context of capital flows, Stiglitz and Weiss (1981) show why interest rates might not adjust to clear credit markets, thus providing an explanation why some countries are permanently rationed at any point in time. But investors can also reassess the probability of default of debtors at any point in time, and more often than not will do so in times of financial crises. This assessment could reflect either a change in fundamentals or contagion effects, and regardless of which occurs in practice, a sudden stop (Calvo and Reinhart (1999)) or collapse in credit (Mankiw (1986)) may follow.

Finally, credit rationing could change with the business cycle as a result of asymmetric information. Because creditors have imperfect information about borrowers, they charge a premium which will vary according to the value of the borrower's collateral. In bad times the value of a firm's collateral falls, the premium charged for its borrowed capital rises, and hence credit falls, thus reinforcing the downturn. This procyclical feature of credit cycles is usually referred to as the financial accelerator mechanism and was described, for example, in Bernanke, Gertler and Gilchrist (1999).

3 Methodology: empirical model and econometric technique

In this paper we assume that it is the lowest of demand of or supply for capital (ie the short side of the market) that determines the amount of capital that flows to emerging economies. In a capital crunch, for example, EMEs' demand for capital inflows exceeds the supply, which in turn reflects the short side of the market. The fact that the short side of the market is what one observes as capital flows can be characterised by the condition:

$$C_t = \min(C_t^d, C_t^s) \quad \textbf{(1)}$$

where C_t^d is the demand for capital at time *t*, C_t^s is the supply of capital at time *t* and C_t is the actual amount of capital inflow.

The supply and demand for capital flows are in turn functions of a set of variables. These functions take the form:

$$C_t^d = \beta' X_t^d + u_t^d \quad \textbf{(2)}$$

$$C_t^s = \gamma' X_t^s + u_t^s \quad \textbf{(3)}$$

where X_t^d and X_t^s are the vectors that determine supply and demand. Some elements of these vectors can be shared by both equations, but exclusion restrictions imply that at least one variable has to be unique to one equation. u_t^d and u_t^s are white noise disturbances while β and γ are parameter vectors. In this paper, we aim to estimate the parameter vectors in the system

(1)-(3), and, in turn, calculate the probability of a capital crunch at any point in time. A capital crunch occurs when

$$C_t = \min(C_t^d, C_t^s) = C_t^s \quad \textbf{(4)}$$

Previous studies that estimate disequilibrium models have tried to infer whether it is demand or supply which determines the short side of the market by looking, for example, at the behaviour of price changes (Fair and Jaffee (1972) and Maddala (1983)). Quantity increases that are associated with an increase in price, for example, should indicate – everything else equal – a shift to the right of the demand schedule, while falling prices (negative changes) reflect a shift to the right of the supply curve. In the context of international capital flows, one could potentially use the extent to which auctions are oversubscribed as a measure of excess demand. These data, however, are difficult to gather as they differ for each specific bond and syndicated loan issuance.

In our methodological framework we instead assume that actual flows belong either to the supply or demand functions with certain probability. We therefore estimate the disequilibrium model with explicit separation of the sample into demand and supply as developed by Kiefer (1980) and Maddala (1983).[5] This model allows one to calculate the probability of being on the supply or demand curve given the observed capital flow at any given point in time.

In particular, denote the probability of a capital crunch at any point in time by θ_t. Hence the probability that any given observation belongs to the supply curve given that we observe the quantity of capital flows, C_t, is:

$$\theta_t = \Pr(C_t^s < C_t^d \mid C_t) \quad \textbf{(5)}$$

If u_t^d and u_t^s are assumed to be independently and normally distributed, the likelihood that an observation belongs to the demand is:

$$L_t^d = (1/\sigma^s)\varphi[(C_t - \gamma' X_t^s)/\sigma^s][1 - \Phi[(C_t - \beta' X_t^d)/\sigma^d] \quad \textbf{(6)}$$

[5] These methods were initially introduced by Fair and Jaffee (1972), Maddala and Nelson (1974), Amemiya (1974), and were later refined by Kiefer (1980) and Maddala (1983).

where φ and Φ are the standard normal density and distribution functions, respectively. Likewise, the likelihood that an observation belongs to the supply is:

$$L_t^s = (1/\sigma^d)\varphi[(C_t - \beta' X_t^d)/\sigma^d][1-\Phi[(C_t - \gamma' X_t^s)/\sigma^s] \quad \textbf{(7)}$$

The likelihood of either occurring is therefore:

$$L_t = L_t^d + L_t^s \quad \textbf{(8)}$$

Hence the likelihood function may be written as (Kiefer (1980) and Maddala (1983)):

$$LF_t = \prod_{t=1}^{T} L_t \quad \textbf{(9)}$$

Intuitively, this form of the likelihood function weights the standard normal distributions that apply to each regime (supply or demand in this case) by the probability of being on the supply or demand given the data. The model can be estimated by maximum likelihood techniques that search for the parameter values that maximise the likelihood function in **(9)**. We implement the estimation procedure using a standard optimisation routine in Matlab.

It follows that the probability of a capital crunch at any point in time, θ_t, as defined in **(5)**, is:

$$\theta_t = L_t^s / L_t$$

which is the likelihood of being on the supply curve normalised by the total likelihood.

Estimating the system of demand and supply in disequilibrium has some advantages but also poses some challenges. The first advantage is that it allows for a more realistic credit market in which, for a variety of reasons, interest rates might not clear supply and demand for capital. A second advantage is that it allows one to separately identify demand and supply equations separately by assessing the probability of being in each regime hence capturing periods of rationing or exuberance.[6] In a more conventional equilibrium demand and supply system, the price variable is said to be endogenous as it is correlated with the error term in either the supply

[6] Other approaches, instead of assigning data to the demand or supply with certain probability, use price changes or auction-cover ratios to make assumptions on whether there is excess demand or supply in the market.

or the demand schedules. However, the simplicity of this framework comes at a cost: the linear supply and demand functions are a simple representation of the possibly more complex supply of capital schedule in a context of imperfect capital markets which could feature credit rationing and asymmetric information. Finally, our maximum likelihood estimation assumes that disturbances to demand and supply are normally distributed, which may not be the case in practice.

4 Data

The capital flows data for this paper comprises a group of eight emerging market economies; Brazil, Chile, China, Colombia, South Korea, Mexico, Poland and Thailand.[7] The capital flows variable is derived by summing together monthly bond and syndicated loan flows for all of these countries for the period 1992:1 – 2004:12. These series, representing *gross* flows, are provided by Dealogic Bond and Loanware. Equity flows are not included in our capital flows variable.[8]

The data set used is larger than that of Mody and Taylor. The choice of right-hand side variables, however, falls prey to the problem of availability and quality of monthly data – preventing an even larger cross-section of EMEs. For consistency, where possible country-specific data are from international financial institutions such as the IMF and World Bank, while market data are used for spreads and interest rates. Only after exhausting these sources have national sources been used.

The choice of right-hand side variables differs slightly from the traditional ‘push-pull’ factors approach. In particular, the joint estimation of a demand and supply system implies that both push factors (usually associated with the external environment) and pull factors (assumed to be domestic attractors) could be part of both the supply and demand functions.

On the supply side, global push factors were experimented with, such as short and long-term US interest rates (yields on one-year Treasury bills and ten-year government bonds, respectively), US high-yield spreads (yields on Moody’s Baa-rated companies less those on Aaa-rated companies), world GDP growth, the VIX index of US stock market volatility, and a measure of expected returns (emerging markets bond yields (EMBI/EMBIG) over the US risk-free rate). Among the country-specific factors that affect the supply of funds we experimented with credit

[7] These countries were chosen because they have the most reliable data covering the longest period possible.
[8] Bondware reports initial public offerings and additional share offerings, but otherwise does not cover cross-border equity flows.

ratings, domestic short-term interest rates, ratio of foreign currency reserves to short-term debt, and stock market returns.

On the demand side, we experimented with indicators of economic activity such as the level and change of consumer prices, the level of the domestic stock market, commodity price inflation, the level and growth rate of domestic industrial production, and the ratio of foreign exchange reserves over imports. The ratio of domestic credit to GDP, and cost of capital measures such as domestic short-term interest rates, the domestic stock market index and EMBI/EMBIG spreads were also experimented with. Tables A and B show theoretical priors for the supply and demand variables that were experimented with.

Table A: Supply variables

Variable	Expected impact on capital supply	Rationale
US one-year Treasury bill (short-term interest rates)	-	Indicates borrowing costs for EMEs, leading to higher probability of default. Also an indicator of global liquidity.
US ten-year bonds (long-term rates)	+ or -	Indicator of expected return to creditors and also indicator of borrowing costs to debtors.
World GDP growth	+	Higher world GDP growth might imply more funds available for investment in EMEs.
US high-yield spreads	-	Higher spreads reflect lower risk appetite and expectations of US slowdown.
EME bond spreads	+	Higher expected return can increase supply of capital.
Domestic short-term interest rates	+	Increase leads to higher expected returns (although possibly also higher risks).
Credit ratings	+	Increase suggests improved fundamentals.
Change in domestic stock market index	+	Increase suggests improved fundamentals.
Reserves / Short-term debt	+	Higher ratio implies higher ability of EMEs to meet its short-run obligations, with lower credit risk.
Bilateral exchange rate volatility	-	Measure of currency risk and financial instability in debtor country.
VIX index of equity-implied volatility	-	Proxy for global market risk aversion, with higher index value indicating higher risk aversion.
Exports / GDP	+	Measure of openness and of ability to service foreign exchange debt.
Fiscal deficit	-	Measure of fiscal fragility.
Public sector debt / GDP	-	Measure of fiscal fragility.
Trade openness ((imports + exports) / GDP)	+	More openness improves growth prospects attracting capital.

Table B: Demand variables

Variable	Expected impact on capital demand	Rationale
Domestic stock market index	+	Signals stronger economic activity, with higher need for investment capital.
Domestic industrial production	+	Indicator of domestic economic activity.
EME bond spreads	-	Higher cost of capital reduces demand for capital.
Reserves / Imports	-	More available reserves to cover imports lowers need for international capital.
Consumer price inflation	-	Indicator of domestic economic activity, with sign dependent on what causes output gap to narrow.
External debt service / Exports	+	Higher debt repayments relative to export inflows increases need for alternative external financing.
External debt / GDP	+	Higher debt requires more capital to finance repayments.
Current account / GDP	-	Surplus indicates less financing needs.

Importantly, EME bond spreads could be positively related to capital flows by reflecting higher expected returns. But they could also be negatively related by capturing default risk. We seek to control for default risk by using credit ratings in our supply equation. In our estimations, we have also allowed for dynamic effects by including current as well as lagged values where relevant.

5 Dealing with the endogeneity problem

Estimating a joint demand and supply system is complicated by the fact that prices and quantities are determined simultaneously. This endogenous relationship introduces an identification problem by which estimating supply and demand simultaneously leads to biased coefficients. The intuition behind these biases is that the pairs of prices and quantities one observes in the data represent equilibrium points in a demand and supply system and hence they could be associated with more than one supply and demand schedule. Chart 2 illustrates this problem of observational equivalence. Ideally, we would like to track movements in one schedule holding the other one constant. As Chart 3 shows, this would guarantee that we are tracing out the supply curve, given movements in the demand curve.

In a standard supply and demand model with no credit market imperfections, estimation of a supply and demand system with a ‘two-stage least squares method’ (2SLS) delivers consistent estimates. The main idea behind this method is to include in the supply (demand) equation at least one exogenous regressor that shifts only the demand (supply) schedule. By allowing for such exclusion restrictions – or instrumental variables – the 2SLS method can give us unbiased supply and demand coefficients.

Chart 2: Observational equivalence

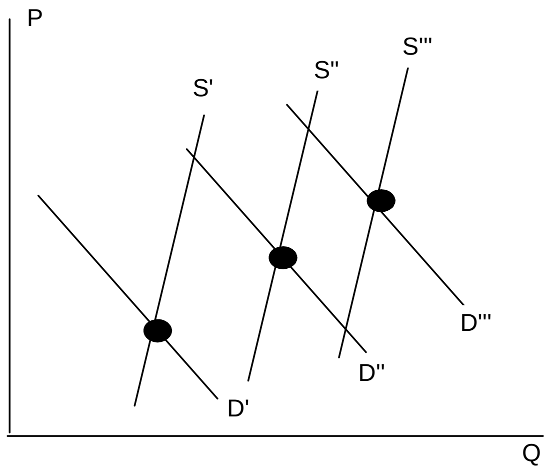
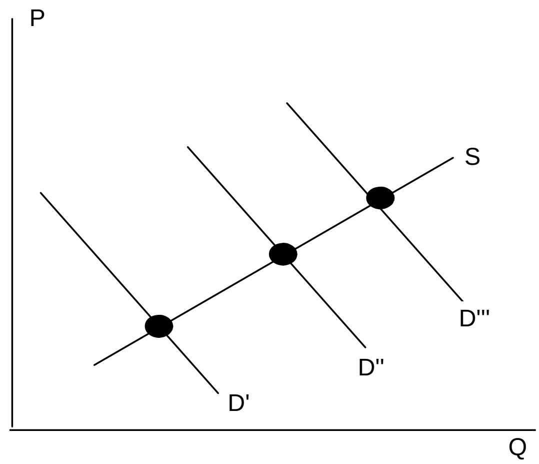


Chart 3: Tracking a supply curve from demand shifts



Our maximum likelihood estimation model is not an equilibrium system, but it still is subject to shocks which could simultaneously shift both demand and supply. Most disequilibrium models impose exogenous prices, assuming away the endogeneity problem. In this paper, however, we go one step further and explicitly try to deal with this problem. We do so by first estimating the model using 2SLS as if the system was in equilibrium. We subsequently use the predicted values for the price variable – EME spreads in our case – in our maximum likelihood estimation to arrive at unbiased supply and demand coefficients for EME capital flows.

6 A useful Monte Carlo experiment using artificial data

To test our maximum likelihood technique, we tried the model on artificial data. This Monte Carlo experiment should allow a qualitative comparison between our technique and a simple OLS estimation. It should also allow us to check if the maximum likelihood technique alleviates the endogeneity problem. The model we consider is as follows:

$$C_t^d = \beta_0 + \beta_1 X_t^d + \beta_2 P_t^d + u_t^d$$

$$C_t^s = \gamma_0 + \gamma_1 X_t^s + \gamma_2 P_t^s + u_t^s$$

$$C_t = \min(C_t^d, C_t^s)$$

$$X_t^d \sim U(0,1),\ P_t^d \sim U(0,1),\ X_t^s \sim U(0,1),\ P_t^s \sim U(0,1),\ u_t^d \sim IN(0, \sigma_{u^d}^2),\ u_t^s \sim IN(0, \sigma_{u^s}^2)$$

The quantities, C, follow the structure of the model. The exogenous variables, X and P, are created artificially using uniform distributions, while the shocks, u, are independent draws from normal distributions. We assume the following initial coefficient values and standard deviations:

$$\beta_0 = 1.5,\ \beta_1 = 2.0,\ \beta_2 = -2.0,\ \sigma_{u^d}^2 = 0.1$$

$$\gamma_0 = 1.0,\ \gamma_1 = 0.5,\ \gamma_2 = 1.0,\ \sigma_{u^s}^2 = 0.25$$

Finally, we use a sample size, N, of 200.

Table C shows the results of this Monte Carlo experiment. The maximum likelihood estimates are close to the true parameters. Given that the quantities data have been generated to suit the theoretical model above, it is not surprising that the maximum likelihood technique delivers good results. The OLS results, on the contrary, differ from the true parameter values, confirming that the OLS coefficients are biased due to the endogeneity of prices and quantities in a supply and demand model.

Table C: Results of the Monte Carlo experiment

	True value	ML	OLS
Supply			
Constant	1.00	0.92 **	1.43 **
X^s	0.50	0.59 **	0.15
P^s	1.00	1.20 **	-0.69 **
Std dev.	0.25	0.26 **	
Demand			
Constant	1.50	1.02 **	0.67 **
X^d	2.00	2.02 **	1.07 **
P^d	-2.00	-2.07 **	-0.77 **
Std dev.	0.10	0.09 **	

** Significant at 5% confidence level

Even though the Monte Carlo confirms the desirability of using a maximum likelihood technique for these purposes, the application to real data might still be problematic. First, the data quality might not be perfect, in which case the inferred probabilities of an observation belonging to the demand or supply curve could be misleading. Second, it is possible that the model is not specified well enough for the estimated coefficients to capture correctly key relationships.

7 Results

7.1 Supply and demand estimates

Table D summarises the maximum likelihood estimation results for our preferred specification of a capital supply and demand system. We need to specify initial values to run the optimisation algorithm that we use to obtain the estimated coefficients that maximise the likelihood function. For this purpose, we use the results from a 2SLS estimation. In the Appendix we report the maximum likelihood estimates without correcting for endogeneity in spreads. We also report the results of estimating the system via 2SLS as well as those of estimating demand and supply separately with OLS. One would expect the OLS estimates to be biased due to the endogeneity problem of supply and demand systems. The results of 2SLS would correct for endogeneity, but not take into account the assumption of imperfect credit markets that we think characterises

EMEs. Finally, the standard maximum likelihood estimates while taking into account the disequilibrium between demand and supply does not correct for the fact that identification could still be a problem in this family of models.

Table D shows results for EMEs as a whole – the main focus of our analysis – as well as for individual countries. On the supply equation, it is interesting to note that higher credit ratings have a positive and significant impact on capital flows to EMEs as a whole – in line with our priors. This result holds also for most individual countries. For EMEs as a whole, spreads are a positive – although not significant – determinant of capital flows. But for most individual countries they are positive and significant, in line with Mody and Taylor's findings. An interpretation of this result is that flows respond positively to higher EME interest rates relative to developed country interest rates because they imply higher returns. The coefficient on world GDP growth is positive and significant. This could imply that higher global growth leads to surplus capital-seeking for higher returns in EMEs. Finally, US high-yield spreads have a negative and usually significant effect on capital flows to EMEs, although again this is not a significant relationship. From a short-term arbitrage point of view, higher high-yield spreads might lead to a cut back in other risky assets such as EME bonds or loans leading to lower EME flows. But from the point of view of the credit cycle, higher high-yield spreads indicate worsening financial balance sheets of firms and reduced access to external sources of finance. This reduced access to loans could lead to a credit slowdown and slower US GDP growth which could reduce flows to EMEs.

Table D: Maximum likelihood estimation of supply and demand of capital flows

	EMEs	Brazil	Chile	China	Colombia	Korea	Mexico	Poland	Thailand
Supply									
Ratings	0.57 **	0.24 **	0.01	0.42	0.31 *	-0.28 **		0.82 **	
Spreads	1.31	0.32 **	0.31 **	1.63 **	0.10	0.34 *	0.44 *	1.07 **	0.85 **
World GDP	0.90 *	0.22 **	0.24 **		0.32 **	0.32 **	0.44 **	0.39 **	-0.28
US high yld	-0.45	-0.30 **	-0.29 **		-0.13	-0.25 **	-0.40 **	-0.48 **	-0.19
Std dev	1.05 **	1.47 **	1.14 **	1.95 **	1.20 **	0.66 **	1.49 **	0.95 **	1.75 **
Demand									
Eqty index	0.32 **	0.43 **	0.37 **	-0.23 **	-0.05	0.56 **	0.17	0.18 **	-0.13
Spreads	-1.10 **	-0.19 **	-0.07	-0.39 **	-0.30	-0.75	-0.13	0.12 *	-0.38
Res/Imp (-1)		-0.12 **	0.04	-0.10 *	-0.50 **	-0.49	-0.03	-0.04	0.36
Com. prices	-0.62 **								
Std dev.	0.85 **	0.74 **	1.16 **	0.60 **	1.08 **	1.57 **	0.84 **	0.59 **	1.96 **

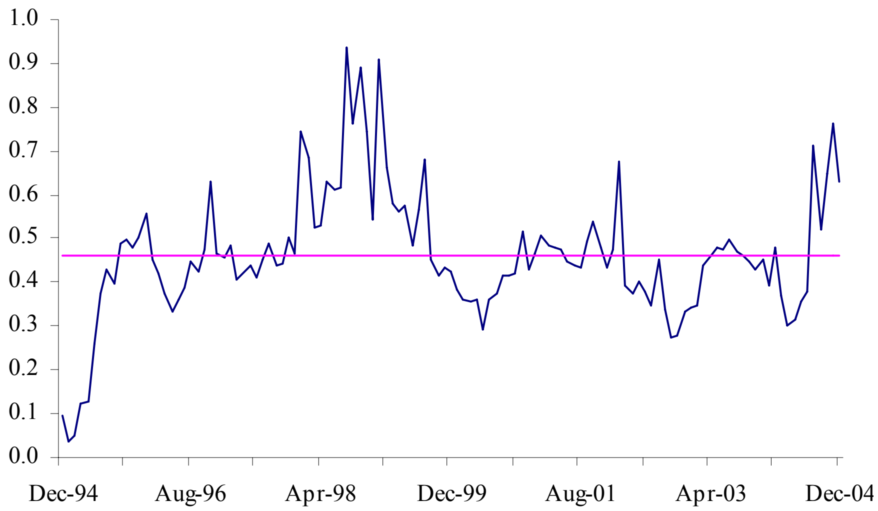
** Significant at 5% confidence level; * significant at 10% confidence level

On the demand side, local equity index levels are a positive (and significant) determinant of capital flows to EMEs as a whole, and for most countries individually. In line with our theoretical priors, higher equity markets could signal stronger domestic economic activity and, therefore, increase a country's demand for external capital to finance its economic growth. Again as expected and in most cases, higher spreads have a negative and significant effect on the demand for capital. In other words, demand declines with a higher cost of capital – an intuitive result. The ratio of foreign exchange reserves to imports, lagged by one period, has a negative relationship to the demand for capital in most countries individually. The higher the level of foreign exchange reserves relative to imports, the lower the needs for external funding, therefore the lower the demand for capital flows. For EMEs as a whole, we use commodity prices instead of reserves over imports. The intuition for this is that, as many EMEs are commodity exporters, when commodity prices rise there is less need for external sources of financing as governments enjoy a cyclical windfall. In line with this, commodity prices have a negative and significant effect on the demand of capital flows.

7.2 Estimating the probability of a capital market crunch

Using the estimated coefficients in the supply and demand equations, the probability of a capital crunch, θ_t, is calculated. Chart 4 plots the three-month moving average of this probability for the period 1994:12 – 2004:12. The probability tracks well some periods of international turmoil that can be associated with credit crunches in EMEs. These episodes are in most cases country-specific crises, say due to negative news about the country's fundamentals. Indeed, several countries might react to events originated in one single country in which case we will observe episodes of contagion across EMEs. But turmoil in EMEs could also be associated with changes in external factors or turmoil in mature markets that could lead to rapid changes in investor sentiment and hence in the supply of flows. This could be the case of widening US high-yield spreads. The probability of a capital crunch is above the period average for the first time in 1995, following the Mexican crisis. It spikes again in 1996 and increases sharply from 1997 to 1999 capturing the Asian crisis (1997) and the Russian/LTCM crisis in 1998/1999. The index then spikes again in 2001, possibly capturing the Argentine crisis. It picks up slightly in 2002/03 at the time of the Brazilian and Turkish crises. Finally, it increases sharply in 2004, possibly in association with a temporary sell-off of EME assets due to expected rises in US policy interest rates.

Chart 4: Probability of capital crunch for EMEs in aggregate



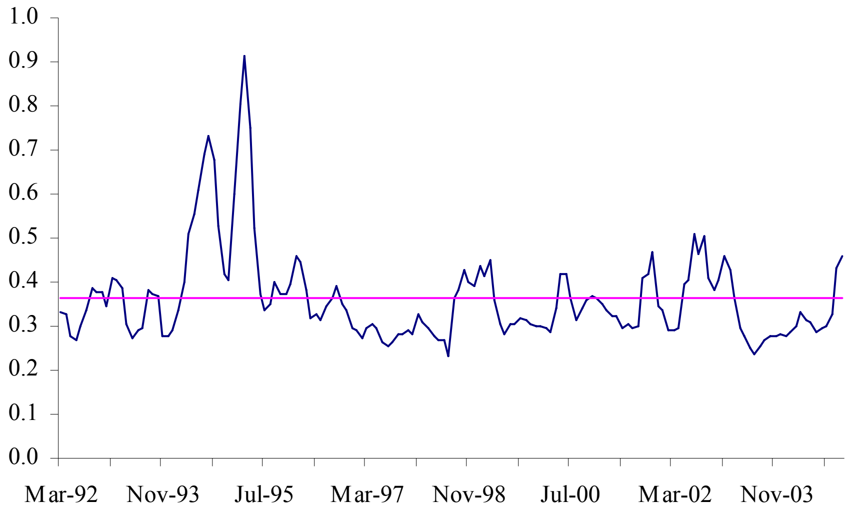
Source: Authors' own calculations

This technique can also be applied to individual countries. We illustrate with Brazil, an important EME country not least in capital flows terms.[9] Chart 5 shows the three-month moving average of the probability of a credit crunch in Brazil for the period 1992:1 – 2005:12. The probability picks up in 1994 and 1995 signalling the turmoil associated with the Mexican crisis. It misses the Asian crisis, but then picks up again in 1998 and 1999 capturing the Russian/LTCM episode as well as the Brazilian (specific) crisis of 1998/99. Interestingly, the

[9] In 2004, Brazil accounted for approximately 9% of total bond and syndicated loans to EMEs.

index also seems to capture the sell-off associated with the US technology sector in 2000/01, the Argentine crisis in 2001 and the turmoil associated with a confidence crisis in Brazil in 2002 and the crisis in Turkey in the same year.

Chart 5: Probability of capital crunch for Brazil



Source: Authors' own calculations

8 Summary and conclusions

This paper estimates a disequilibrium demand and supply system of capital flows to EMEs. The aim of this set-up is to explicitly acknowledge that the supply of international capital might not always match its demand. This should hold in particular for EMEs. The model is estimated using maximum likelihood techniques. These allow for the identification of the determinants of both supply and demand and to estimate the probability of a capital crunch affecting EMEs at different points in time. We view this as a useful framework because it captures the relative importance of domestic and external factors separately on the supply of and demand for capital in EMEs. This system allows us to deepen our understanding of past crises and could also prove helpful when trying to forecast capital flows by monitoring the evolution of supply and demand factors.

The supply results for a combined group of EMEs show that, once the endogeneity of spreads is accounted for, the supply of capital inflows is positively associated with EME spreads. Credit ratings and world GDP growth are also positively related with the supply of capital to EMEs, while US high-yield spreads are negatively associated with them. On the demand side, our equation for EMEs is downward sloping in spreads. It responds negatively to the ratio of foreign exchange reserves over imports and positively to equity prices.

The maximum likelihood estimates are used to calculate the probability of a capital crunch in the EMEs asset class. This probability captures most of the recent crisis episodes that are typically associated with sharp falls in the supply of capital to EMEs. As an example, this method is applied to Brazil. The probability of a capital crunch also captures several periods of turmoil that affected the supply of capital to Brazil.

The results show that capital flows to EMEs are subject to domestic and external influences, but these movements might be associated with shocks to supply or demand. This is important for policymakers and EME analysts as it separates – based on past experiences – where the source of vulnerability lies. Similarly, this could shed light on identifying sources of vulnerabilities going forward, especially in a context where EMEs' fundamentals, as well as their demand for capital, are getting stronger.

Further work could involve estimating the supply and demand model for more countries, but this would imply expanding the choice of determinants as each EME varies extensively in terms of their policy arrangements, their stage of development, and the availability of data.

Appendix: OLS, 2SLS and maximum likelihood results without instrumental variables

Table A1: Supply estimates – EMEs and individual countries

	EMEs	Brazil	Chile	China	Colombia	Korea	Mexico	Poland	Thailand
OLS									
Ratings	0.14 **	0.15 **	0.10	-0.18 **	0.33 **	-0.18 *	0.02	0.45 **	
Spreads	-0.52 **	-0.25 **	0.05	-0.06	0.05	0.08	0.24 **	0.27 **	0.48 **
World GDP	0.17 **	0.17 **	0.21 **		0.27 **	0.32 **	-0.20 **	0.25 **	-0.12 *
US high yld	0.13 **	-0.17 **	-0.15 **		-0.18 *	-0.01	0.06	-0.15 *	-0.08
Adj-R^2									
2SLS									
Ratings	0.53 **	0.16 **	-0.07	0.24 **	0.37 **	-0.21 *		0.81 **	
Spreads	1.59 **	0.37 **	0.42 **	0.87 **	0.17	0.12	0.17 *	1.17 **	0.59 **
World GDP	0.96 **	0.29 **	0.27 **		0.26 **	0.32 **	0.27 **	0.35 **	-0.18 **
US high yld	-0.73 **	-0.24 **	-0.34 **		-0.22 **	-0.03	-0.28 **	-0.56 **	-0.06
Adj-R^2									
ML (Without IV)									
Ratings	0.20 *	-0.15 **	0.12	-0.03	0.34 **	-0.20 **	0.13	0.51 **	
Spreads	-0.40 **	-0.33 **	0.06	-0.07 **	0.05	0.23 **	0.37 **	0.26	0.70 **
World GDP	0.29 **	0.07	0.20		0.32 **	0.31 **	-0.28 *	0.30 **	-0.21
US high yld	0.11	-0.19 *	-0.17		-0.15	-0.21 **	0.14	-0.14	-0.23
Std dev	0.99 **	1.48 **	1.15 **	0.63 **	1.19 **	0.65 **	1.54 **	1.01 **	1.77 **

Table A2: Demand estimates – EMEs and individual countries

	EMEs	Brazil	Chile	China	Colombia	Korea	Mexico	Poland	Thailand
OLS									
Eqty index	0.34 **	0.44 **	0.36 **	-0.38 **	-0.02	0.38 **	0.06	0.16 *	0.24 **
Spreads	-0.62 **	-0.41 **	0.00	-0.19 **	-0.05	-0.16	-0.17	-0.12 *	0.30 **
Res/Imp (-1)		-0.16 **	0.00	-0.02	-0.40 **	0.04	-0.07	0.35 **	-0.05
Com. prices	-0.17 **								
Adj-R^2									
2SLS									
Eqty index	0.38 **	0.43 **	0.36 **	-0.55 **	-0.05	0.33 **	0.06	0.09	0.22 **
Spreads	-0.99 **	-0.29 **	-0.10	-0.54 **	-0.28 **	-1.44 **	-0.17	-0.25 **	0.32 **
Res/Imp (-1)		-0.14 **	0.03	-0.06	-0.44 **	-1.13 **	-0.07	0.36 **	-0.05
Com. prices	-0.44 **								
Adj-R^2									
ML (Without IV)									
Eqty index	0.32 **	0.43 **	0.37 **	-0.23 **	-0.05	0.56 **	0.17	0.18 **	-0.13
Spreads	-1.10 **	-0.19 **	-0.07	-0.39 **	-0.30	-0.75	-0.13	0.12 *	-0.38
Res/Imp (-1)		-0.12 **	0.04	-0.10 *	-0.50 **	-0.49	-0.03	-0.04	0.36
Com. prices	-0.62 **								
Std dev.	0.85 **	0.74 **	1.16 **	0.60 **	1.08 **	1.57 **	0.84 **	0.59 **	1.96 **

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