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Hot money, accounting labels and the permanence of capital flows to developing countries: an empirical investigation

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Abstract

Using maximum likelihood Kalman filtering techniques and non-parametric variance ratio statistics, we gauge the relative importance of permanent and temporary components of capital flows to Latin American and Asian developing countries over the period 1988–1997, for the broad categories of flows in the capital account: equity flows (EF), bond flows (BF), official flows (OF), commercial bank credit (BC), and foreign direct investment (FDI). We find relatively low permanent components in EF, BF and OF, while commercial BC flows appear to contain quite large permanent components and FDI flows are almost entirely permanent. These results have a natural interpretation and clear policy implications. © 1999 Elsevier Science B.V. All rights reserved.

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1. Introduction

This paper examines the permanence of capital flows to Latin American and Asian developing countries over the period 1988–1997. The 1990s saw a very

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sharp expansion of net and gross capital flows to developing countries from the developed world (World Bank, 1997). [1] Once it is accepted that a surge in capital inflows to a developing country may require compensatory policies to offset any adverse effects on the recipient economy (see, e.g., World Bank, 1997, Chap. 4), then gauging the degree of permanence of any particular capital flow becomes crucial for appropriate policy design. [2] This is particularly important since it is now increasingly recognised that accounting labels such as 'short-term' or 'long-term' may be an unreliable guide as to the degree of 'hotness' (temporariness) or 'coolness' (permanence) of a capital flow (Claessens et al., 1995). [3]

Another important feature of the recent trend in capital flows to developing countries is that *private* capital flows are increasingly a crucial source of financing of large current account imbalances, significantly dwarfing *official* flows (OF) in terms of relative importance. Bruno (1993), for example, estimates that, in the early 1990s, close to half of all aggregate external financing of developing economies came from private sources and went to private destinations, and the (World Bank, 1997, p. 9) estimates that private capital flows are now five times the size of OF. The 1990s also saw a considerable broadening in the composition of private capital flows to developing countries relative to the 1980s. Foreign direct investment (FDI) now represents the most important component of private capital flows, followed by portfolio (equity and bond) flows, which were virtually negligible until the late 1980s. On the other hand, commercial bank credit (BC) flows, which accounted for over 65% of all private flows in the late 1970s and early 1980s, declined very significantly in terms of relative importance during the 1990s (World Bank, 1997). These trends in the pattern of capital flows raise important issues concerning the factors which determine them, how these flows affect and are expected to affect the economic performance of developing countries, and how permanent or temporary they are expected to be.

The present paper contributes to the literature on this topical and important research in that we measure the relative size and statistical significance of the permanent and temporary components of various categories of capital flows to a

[1] For a comprehensive review of some recent prospects and developments concerning capital flows to developing countries, see *Private Capital Flows to Developing Countries: The Road to Financial Integration* (World Bank, 1997), *World Investment Report: Transnational, Market Structure and Competition Policy* (United Nations, 1997), *Trends in Developing Economies* (World Bank, 1995), *International Capital Markets: Developments, Prospects, and Policy Issues* (IMF, 1994, pp. 83–91), *Private Market Financing for Developing Countries* (IMF, 1995). Important, slightly earlier studies include Goldstein et al. (1991) and Montiel (1993).

[2] See, e.g., Corbo and Hernandez (1993, 1996), Kiguel and Caprio (1993), Agenor and Montiel (1996), Fernandez-Arias and Montiel (1996), World Bank (1997), and Razin et al. (1998).

[3] The importance of determining the degree of permanence of capital inflows in determining appropriate policy responses is also stressed by Gooptu (1993), Nunnenkamp (1993), Reisen (1993), Corbo and Hernandez (1993, 1996), Claessens et al. (1995), Hernandez and Rudolph (1995), and Dooley et al. (1996).

large group of Latin American and Asian developing countries during the sample period 1988–1997, distinguishing between the broad categories of flows in the capital account—equity flows (EF), bond flows (BF), OF, commercial BC, and FDI (see Section 2). [4]

The remainder of the paper is set out as follows. In Section 2, we provide a brief overview of some of the issues raised by the recent increase in international capital flows to developing countries, discuss the relevance of their degree of permanence from the policy-making point of view, and establish our priors as to the expected time series properties of the various capital account items. In Section 3, we discuss the data set used and, in Section 4, we describe the estimation techniques employed in order to model capital flows to developing countries and measure their permanence. In Section 5, we report and discuss the empirical results. Section 6 concludes.

2. International capital flows, 'hot money' and macroeconomic policy

A standard treatment of the desirability of capital flows to developing countries might stress the comparative advantage aspect of such transactions, with the gains from capital flows mirroring the gains from trade in goods and services: recipient countries receive funds for investment which would not normally be available from domestic sources, while investing countries receive a higher return (adjusted for risk) than would be available in the developed world. [5] Equivalently, capital flows represent intertemporal trade in goods and services, since developing country capital account surpluses now are the obverse of current account deficits which represent an excess of domestic investment over domestic saving and which should be reversed in the future. Arguments for the free flow of capital may then be seen as underpinned by arguments for the gains from intertemporal trade.

A number of authors—including those of the recent World Bank report (World Bank, 1997)—have, however, stressed the point that capital inflows to developing countries may also have deleterious side effects on the recipient economies which may require offsetting action by the recipient economy authorities. Given this, the

[4] The focus of our analysis is thus less on isolating the underlying determinants of capital flows—an issue addressed in papers such as Chuhan et al. (1993, 1998), Fernandez-Arias (1996), Taylor and Sarno (1997) and Agenor (1998)—and more on measuring the characteristics of the flows themselves, in particular, the relative size of their temporary and permanent components (see, e.g., Claessens et al., 1995).

[5] The rates of return available on various categories of capital rose significantly in many developing countries during the late 1980s relative to those available in major industrialized economies (Calvo et al., 1993, 1996; Chuhan et al., 1993, 1998; Frankel and Okongwu, 1996). Credit ratings and secondary market prices of sovereign debt, reflecting the opportunities and risks of investing in the country, are also likely to be important factors in determining capital flows (e.g., Bekaert, 1995; Tesar and Werner, 1995); those indicators also experienced a rising trend in the late 1980s (e.g., Mathieson and Rojas-Suarez, 1992; Chuhan et al., 1993, 1998; Reisen and Fischer, 1993).

importance of gauging the degree of permanence of any particular category of capital flow becomes clear. On the one hand, the authorities may wish to weigh the costs of designing and implementing a particular macroeconomic policy in order to offset the harmful side-effects of a particular capital inflow, against the perceived permanence of that flow. On the other hand, the authorities may wish to insulate the economy against the possible sudden reversal of capital flows which are deemed to have large temporary, reversible components. The recent World Bank report (World Bank, 1997) echoes the concerns of many writers on this subject when it calls for the appropriate design of macroeconomic policies in response to capital inflows. [6]

Corbo and Hernandez (1993, 1996) and Kiguel and Caprio (1993), for example, describe a number of cases of policy responses adopted by developing countries in response to the increase of ‘hot money’ inflows. These include exchange rate policies, fiscal policy, sterilization policies or changes in reserve requirements. Fernandez-Arias and Montiel (1996) summarize a number of arguments to justify why large temporary portfolio flows may not be desirable and may potentially perversely affect developing countries unless proper policies designed to neutralize them are adopted. The World Bank (1997), among others, have argued, for example, that strong surges in portfolio inflows to developing countries may generate asset market bubbles—an observation which seems to have been borne out by the recent East Asian crisis (see, e.g., Krugman, 1998).

On this argument, then, gauging the degree of permanence of capital flows to developing countries is extremely important, since their reversibility can potentially generate high adjustment costs arising from resource reallocation, sunk costs and other hysteresis effects, or other market imperfections, and the country concerned should, moreover, try to avoid a long and difficult adjustment process on the basis of capital flows which may be reversed later. [7]

In an influential paper (Claessens et al., 1995), using balance of payments capital account data for a range of developing countries, show that the accounting labels ‘short-term’ and ‘long-term’ as traditionally applied to capital flows do not provide any reliable indication as to the degree of persistence or ‘coolness’ of the

[6] See also Kaminsky and Reinhart (1998a) for an empirical investigation of the extent to which past financial crises share common characteristics in Latin America, Asia, Europe and the Middle East, as well as an examination of the recent crises in Asia and Latin America in order to determine the extent to which the considerable regional differences of the past have eroded over time. Kaminsky and Reinhart (1998b) also analyze the link between banking and currency crises for a number of countries, providing evidence that problems in the banking sector typically precede a currency crisis; the currency crisis deepens the banking crisis, activating a vicious spiral; financial liberalization often precedes a banking crisis; and these episodes may be explained by common macroeconomic causes, typically when a country enters a recession following a prolonged boom in economic activity that is usually fueled by credit, large capital inflows and domestic currency overvaluation.

[7] As noted by Corbo and Hernandez (1993): ‘‘Reversing an initial adjustment could be quite costly if there are irreversible costs involved... This is particularly relevant in the case of hot money.’’

flows. They argue, moreover, that relying on the accounting label rather than the actual time series properties of capital flows for policy purposes may generate potentially disastrous results.[8] Thus, the importance of investigating the time series properties of capital flows to developing countries—the focus of the research reported in this paper—becomes clear.

Capital flows to developing countries may be classified into four broad categories: private portfolio flows—which may be further sub-divided into BF and EF (i.e., developing country company share purchase) flows; commercial bank lending from developed to developing countries; FDI, whereby a firm largely owned by residents in a developed country acquires or expands a factory or subsidiary firm located in a developing country; and OF, representing loans from international agencies such as the World Bank and the International Monetary Fund, as well from developed country governments. Before analysing the time series properties of these various categories of flows and, in particular, their degree of persistence, it is useful to set out one's prior expectations concerning the degree of permanence or persistence on might expect for each of them.

In forming a prior for the degree of permanence of flows of FDI, one must distinguish between the degree of reversibility of the flows and of the actual physical investment itself. There is an important literature on the sunk costs nature of much physical investment (see, e.g., Dixit and Pindyck, 1994). Granting that physical investment in a developing country may be largely irreversible, however, does not imply that the *flows* of funds for such investment are themselves irreversible. To give a simple example, once a firm has invested in plant and machinery in a country, then it is very hard or indeed impossible to reverse that investment. On the other hand, if the investment is one-off, then the resulting time series for FDI investment flows will appear to be temporary—only occurring over a short period while the plant and machinery are being built and installed and then ceasing. One might argue, however, that where a firm has made a direct investment in a country, then it will almost certainly have thoroughly examined the underlying economic fundamentals and is less likely to be influenced by financial market inefficiencies such as herding effects, so that FDI flows might be expected to be more permanent than portfolio flows. Also, although the irreversible nature of much physical investment is not the same as the irreversibility or otherwise of the FDI flows themselves, there may be some link between the two in that once a firm has made a commitment to a particular country through FDI, then the less likely it is to decide suddenly to start investing in alternative locations elsewhere. Moreover, there are likely to be important signalling effects

[8] Dooley (1995), for example, argues that the 1982 debt crisis was in part generated by the imprudence of private investors induced by capital flows to developing countries in the 1970s which, although labeled as private, should really have been considered as official in that a general governmental guarantee underlay them.

in FDI in the sense that once a firm makes a largely irreversible investment in a particular country, this commitment signals to other firms a belief that that country is safe to invest in (in terms of market access and/or its governance and institutions), thus, encouraging further FDI. Of the various categories of inflows, therefore, FDI may perhaps be expected to have a large permanent component.

Portfolio flows (i.e., EF and BF), on the other hand, might be expected to be significantly more volatile then FDI flows and—with increasing deregulation and decreasing transactions costs—more sensitive to movements in short-term differentials in rates of return. Also, given that emerging markets are still underweighted in foreign investors' portfolios (World Bank, 1997) and that foreign investors are still relatively unfamiliar with emerging markets, these markets may be quite susceptible to cyclical conditions in major industrialized countries and more prone to investor herding behavior than industrial countries' financial markets (World Bank, 1997). [9]

A priori, then, we might expect portfolio—bond and equity—flows and FDI flows to define the most volatile or temporary and least volatile or permanent capital-account items respectively. The remaining category of private capital flows, commercial BC—the least important fraction of private capital flows to developing countries in the 1990s in terms of relative size—one might expect to have an important persistent component. In particular, because of the illiquidity of commercial loans to developing countries once they are made, one might expect commercial banks to look more closely at the underlying economic fundamentals before committing funds and therefore to be less prone to sudden changes of heart. Moreover, once funds are committed in this way, it may seriously jeopardise a bank's chances of recovering its investment if lending is suddenly withdrawn. Hence, the permanent component in commercial BC time series may reasonably be expected to be relatively large and perhaps to dominate the transitory component, albeit to a lesser extent than for FDI flows.

It is perhaps a little harder to form strong priors concerning the degree of permanence of OF to developing countries. Although OF have been considerably dwarfed by private capital flows to developing countries in the 1990s (World Bank, 1997, p. 9), they still remain of some importance for various low-income developing countries. More generally, OF continue to play a valuable complementary role to private capital flows for a number of reasons, such as sustaining improvements in the policy and institutional framework, and acting as a catalyst

[9] Indeed, portfolio EF to developing countries may be expected to be sensitive to the degree of openness of the country considered, and in particular to the rules concerning the repatriation of capital and income (Goldstein et al., 1991; Papaioannu and Duke, 1993; Williamson, 1993). The International Finance differentiates between countries which give foreign investors free and unrestricted repatriation of capital and income from equity investment, and countries, defined 'relatively open', which apply some restrictions on the repatriation of capital and income, and still other countries, defined 'relatively closed', which apply very strict restrictions to the way in which capital may be repatriated.

for private flows in countries with increasingly sound macroeconomic policies (World Bank, 1997, pp. 66–71). Given that OF are largely under the control of international agencies and national governments, one might perhaps expect them to be more persistent than private portfolio flows. On the other hand, a developing country may have recourse to OF in order to compensate for reversals in other categories of the capital account, and to that extent OF may be largely picking up the residual effects of those other flows. Overall, therefore, general priors for the permanence of OF are hard to determine.

We now turn to a discussion of the data employed in our empirical analysis of how far these priors are satisfied.

3. Data

We employ a data base on the various categories of US capital flows to nine Asian and nine Latin American countries from the beginning of 1988 through to the end of 1997. The nine Asian countries considered are China, India, Indonesia, Korea, Malaysia, Pakistan, Philippines, Taiwan and Thailand. The nine Latin American countries considered are Argentina, Brazil, Chile, Colombia, Ecuador, Jamaica, Mexico, Uruguay and Venezuela. [10] For US portfolio (equity and bond) flows and OF to these countries, the frequency of our data base is monthly. These time series were constructed using the *International Capital Reports* of the US Treasury Department. [11] Following a number of studies, we use net EF and gross BF to developing countries, which cover a substantial share of portfolio flows to those countries, [12] since even if in principle we are concerned with modelling net capital flows, it seems preferable to use gross measures for BF in order to abstract from the effect of sterilization policy actions and other types of reserve operations

[10] These are the same countries considered by Chuhan et al. (1993, 1998) and Taylor and Sarno (1997).

[11] Quarterly data are published in the *US Treasury Bulletin*, while monthly data are now available from the website of the US Treasury Department. Most of these data are collected by the Treasury from financial intermediaries in the US through the International Capital Form S reports. Hence, the data do not include direct dealings of US investors with foreign intermediaries as these transactions bypass the system. Note also that the data on bonds cover transactions of foreign securities in the US from and to developing countries; transactions in bonds not issued by the developing country concerned nor by US parties are expected to be quite insignificant (see Chuhan et al., 1993, 1998, pp. 446–451; Tesar and Werner, 1994; Taylor and Sarno, 1997).

[12] *Net* capital flows arise when savings and investment are unbalanced across countries, and therefore a transfer of real resources is generated through a trade or current account imbalance. *Gross* capital flows, on the other hand, need not involve any transfer of real resources, since they may be offsetting across countries. Nevertheless, they allow individuals and firms to adjust the composition of their financial portfolios and are therefore important in improving the liquidity and diversification of portfolios.

by the monetary authorities (see, e.g., Chuhan et al., 1993; Taylor and Sarno, 1997).

Quarterly data on US commercial BC flows to the same developing countries were taken from the *US Treasury Bulletin* (Capital Movements Section, Table CM-II-2) which presents claims on foreigners reported by US banks and other depository institutions, brokers, and dealers.[13] Also, quarterly data for FDI to those developing countries were taken from the diskette *US Direct Investment Abroad* of the US Department of Commerce.[14]

The sample period runs from 1988M1 to 1997M12 for EF, BF and OF, and from 1988Q1 to 1997Q4 for the series on BC and FDI, therefore, providing us with a 10-year observation period during which both inflows and outflows have occurred before and after the Mexican crisis, and spanning until a few years after the ending of the downturn in US interest rates.

4. Estimation techniques

4.1. Unobserved components

The persistence of capital flows can be examined by employing the unobserved components model suggested by Harvey (1981, 1989). The essential idea is to break the time series down into unobserved permanent and temporary components using maximum likelihood estimation. Consider a panel data set of N countries with capital flows of a certain category for the ith country at time t generically denoted f_{it}. The unobserved components model may be written.[15]

$$f_{it} = \mu_{it} + \nu_{it} + \epsilon_{it} \qquad i=1,\dots,N;\ t=1,\dots,T \tag{1}$$

where f_{it} may be any of the capital-account items discussed in Sections 2 and 3, μ_{it} is a trend component, the irregular component ε_{it} is approximately normally independently distributed with zero mean and constant variance and ν_{it} represents a first-order autoregressive, AR(1) component:

$$\nu_{it} = \rho_{\nu_i} \nu_{it-1} + \xi_{it} \tag{2}$$

where ξ_{it} is approximately normally independently distributed with zero mean and

[13] In fact, data on bank claims held for their own account are collected monthly. However, information on claims held for their domestic customers as well as foreign currency claims is collected only on a quarterly basis and, therefore, relatively reliable and comprehensive data on BC are only available on a quarterly basis.

[14] These data are also published in the *Survey of Current Business* of the US Department of Commerce.

[15] A possible extension of the model would be to consider one or more cyclical components. We neglect this possibility because, in our empirical analysis, the inclusion of a cycle in the model was not found to improve the goodness of fit on the basis of the prediction error variance and the AIC.

constant variance, and the autoregressive coefficient is constrained to be less than unity in absolute value in order to ensure stationarity of the component. [16]

The stochastic trend component is modelled as:

$$\mu_{it} = \mu_{it-1} + \beta_{it-1} + \eta_{it} \tag{3}$$

and

$$\beta_{it} = \rho_{\beta_i} \beta_{it-1} + \zeta_{it} \tag{4}$$

where β_{it} represents the slope or gradient of the trend component μ_{it} and ρ_{β_i} represents the damping factor, while each of the disturbances η_{it} and ζ_{it} is approximately normally independently distributed with zero mean and constant variance.

The irregular component ε_{it}, the level disturbance η_{it} and the slope disturbance ζ_{it} are mutually uncorrelated. The slope component may be treated as fixed rather than stochastic and also excluded from the trend specification when this is appropriate.

Intuitively, Eq. (1) expresses the capital flow as the sum of a permanent component (μ_{it}), a purely temporary, zero persistence component (ε_{it}) and a more slowly decaying temporary component (ν_{it}). In addition, the drift in the random walk component (β_{it}) may itself vary over time. Thus, the model separates out the persistent and temporary components of the data in a very general, comprehensive fashion. [17]

The statistical treatment of the unobserved components model outlined above is conveniently handled by writing it in state space form (SSF) involving a measurement equation relating the unobserved components (the state vector) to an observed series, together with a transition equation governing the evolution of the

[16] The need to impose stationarity on the AR(1) process arises because of the risk of it being confounded with the random-walk component in the trend specification, in which case the model effectively be unidentified.

[17] Note that the structural time series model outlined above also nests an I(2) process for f_{it}. In particular, ignoring the AR(1) component and dropping the country subscript i for ease of exposition, the first difference of f_t, Δf_t, may be written as:

$$\Delta f_t = \beta_{t-1} + \eta_t + \epsilon_t - \epsilon_{t-1}$$

Since $\beta_{t-1} = \rho_\beta \beta_{t-2} + \zeta_{t-1}$, if $\sigma_\zeta = 0$ or $\rho_\beta = 0$, then Δf_t is the sum of an MA(1) process and a white noise process, so that $f_t \sim$ I(1): $f_t \sim$ ARIMA(0,1,1) (Granger and Morris, 1976). If $\sigma_\zeta \neq 0$, however: (a) if $\rho_\beta = 1$ then $\Delta^2 f_t$ is the sum of a white noise process, an MA(1) and an MA(2) so $f_t \sim$ I(2): $f_t \sim$ ARIMA(0,2,2) (ibid.); (b) if $|\rho_\beta| < 1$, then Δf_t is the sum of a stationary AR(1), an MA(1) and white noise so $f_t \sim$ I(1): $f_t \sim$ ARIMA(1,1,2) (ibid.). Nevertheless, the finding—discussed in Section 5—that the stochastic slope is not found to be statistically significantly different from zero at conventional nominal levels of significance clearly implies that all the series modelled in this paper are first-difference stationary, which also accords with the evidence, reported below, from executing unit root tests. This taxonomy also illustrates how the structural time series model may be viewed as a means of interpreting low-order ARIMA processes in terms of permanent and temporary components.

state vector. The SSF corresponding to the model outlined in Eqs. (1)–(4) may be written as:

$$f_{it} = (1\,0\,1)\begin{pmatrix}\mu_{it}\\ \beta_{it}\\ \nu_{it}\end{pmatrix} + \epsilon_{it} \tag{5}$$

$$\begin{pmatrix}\mu_{it}\\ \beta_{it}\\ \nu_{it}\end{pmatrix} = \begin{pmatrix}1 & 1 & 0\\ 0 & \rho_{\beta_i} & 0\\ 0 & 0 & \rho_{\nu_i}\end{pmatrix}\begin{pmatrix}\mu_{it-1}\\ \beta_{it-1}\\ \nu_{it-1}\end{pmatrix} + \begin{pmatrix}1 & 0 & 0\\ 0 & 1 & 0\\ 0 & 0 & 1\end{pmatrix}\begin{pmatrix}\eta_{it}\\ \zeta_{it}\\ \xi_{it}\end{pmatrix} \tag{6}$$

where Eq. (5) represents the measurement equation, which shows how an observed series is related to the state vector, whereas Eq. (6) is the transition equation, describing the dynamic evolution of the state vector. The SSF given by Eqs. (5) and (6) may itself be written—dropping the country subscript for clarity—in a more compact form, using obvious notation, as:

$$f_t = \mathbf{z}'\boldsymbol{x}_t + \epsilon_\rho \qquad t = 1,\dots,T \tag{7}$$

$$\boldsymbol{x}_t = \mathbf{M}\,x_{t-1} + \mathbf{R}\,\kappa_\rho \qquad t = 1,\dots,T \tag{8}$$

where:

$$\epsilon_t \sim IN(0,\sigma^2) \tag{9}$$

$$\kappa_t \sim IN(0,\sigma^2\mathbf{Q}) \tag{10}$$

$\mathbf{z}'$ is a known (3×1) vector, $\mathbf{M}$ and $\mathbf{R}$ are fixed matrices of order (3×3), and $\mathbf{Q}$ is also a fixed (3×3) matrix. The (3×1) vector $\boldsymbol{x}_t$ is the unobservable state vector.

Given knowledge of the parameters of the SSF, the Kalman filter provides us with optimal estimates of $\boldsymbol{x}_t$, using either information up to time $t-1$ (the prediction equations), information up to time t (the updating equations), or the full sample information (the smoothing equations) (Kalman, 1960a,b). [18]

Suppose we have an optimal estimator of x_{t-1} using all information up to time $t-1$, and denote this X_{t-1}. Then, the prediction equation providing us with the optimal predictor of $\boldsymbol{x}_t$ using information up to time $t-1$, denoted $X_{t|t-1}$ is:

$$X_{t|t-1} = \mathbf{M}\,X_{t-1} \tag{11}$$

and the covariance matrix of $X_{t|t-1}$ can be shown to be given by:

$$\mathbf{P}_{t|t-1} = \mathbf{M}\mathbf{P}_{t-1}\mathbf{M}' + \mathbf{R}\mathbf{Q}\mathbf{R}' \tag{12}$$

where $\mathbf{P}_{t-1}$ is the covariance matrix of $X_{t|t-1}$. Eqs. (11) and (12) describe the prediction equations of the Kalman filter.

[18] See Harvey (1989) or Cuthbertson et al. (1992) (Chap. 7) for an accessible introduction to the Kalman filter.

The updating equations, which update these predictions on the basis of information at time t, are given by Eqs. (13) and (14):

$$X_t = X_{t|t-1} + \mathbf{P}_{t|t-1} z\left(f_t - \mathbf{z}' X_{t|t-1}\right)/g_t \tag{13}$$

$$\mathbf{P}_t = \mathbf{P}_{t|t-1} - \mathbf{P}_{t|t-1} z \mathbf{z}' \mathbf{P}_{t|t-1}/g_t \tag{14}$$

where $g_t = \mathbf{z}' \mathbf{P}_{t|t-1} z + 1$. [19]

Given a finite sequence of observations f_t, the only state vector estimator which uses all the available information is X_T. The smoothing equations, given by Eqs. (15) and (16), describe optimal, full-sample information estimators:

$$X_{t|T} = X_t + \mathbf{P}_t^* \left(X_{t+1|T} - \mathbf{M} X_t\right) \tag{15}$$

$$\mathbf{P}_{t|T} = \mathbf{P}_t - \mathbf{P}_t^* \left(\mathbf{P}_{t+1|T} - \mathbf{P}_{t+1|t}\right) \mathbf{P}_T^{*\prime} \tag{16}$$

where $\mathbf{P}_t^* = \mathbf{P}_t \mathbf{M}/\mathbf{P}_{t+1|t}$, $X_{T|T} = X_T$ and $\mathbf{P}_{T|T} = \mathbf{P}_T$. Eqs. (11)–(16) describe the Kalman filter recursions (Kalman, 1960a,b).

The state space parameters can in practice be estimated by maximum likelihood methods (Harvey, 1989; Cuthbertson et al., 1992). A natural by-product of the Kalman filter recursions is a sequence of one-step-ahead prediction errors, u_t, defined by:

$$u_t = f_t - \mathbf{z}' X_{t|t-1} \tag{17}$$

Using a result due to Schweppe (1965), the likelihood function for the sample, Ł$(\cdot)$, can be derived and expressed in terms of the innovations u_t and their variances, g_t:

$$£ = -\frac{T}{2}\ln 2\pi - \frac{T}{2}\ln\sigma^2 - \frac{1}{2}\sum_{t=1}^{T}\ln g_t - \frac{\sigma^{-2}}{2}\sum_{t=1}^{T}\frac{u_t^2}{g_t} \tag{18}$$

The likelihood function obtained can then be maximized with respect to the parameters [20] using numerical optimisation procedures (e.g., Cuthbertson et al., 1992, Chap. 2). In our empirical work, we employ the Broyden–Fletcher–Gold-

[19] The term $(f_t - \mathbf{z}' X_{t|t-1})$ in Eq. (13) is the prediction error. This innovation contains all the new information in f_t and is used to update $\boldsymbol{x}_t$ via the Kalman gain, which is the (3×1) vector $(\mathbf{P}_{t|t-1} z)/g_t$ which essentially decides what weight to assign to the innovation.

[20] The scale factor σ^2 may always be concentrated out of Eq. (18) by substituting:

$$\hat{\sigma}^2 = \frac{1}{T}\sum_{t=1}^{T}\frac{u_t^2}{g_t}$$

so that the maximization of the likelihood function becomes equivalent to minimizing the function:

$$F = T\ln\hat{\sigma}^2 + \sum_{t=1}^{T}\ln g_t$$

Concentrating σ^2 out of the likelihood function reduces the dimension of the search involved in the numerical optimisation procedure.

farb–Shanno quasi-Newton algorithm (Harvey, 1981), based on three convergence criteria—changes in the likelihood kernel, the gradient and the parameters.

The estimated variance parameters indicate the relative contribution of each component in the state vector to explaining the total variation in the time series under consideration. In some sense, therefore, the estimated variances allow us—by providing information on the size of the nonstationary and the stationary components in the series—to quantify the degree of persistence of the series in question. If a large and statistically significant proportion of the variation in flows is attributed to the stochastic level, for example, then one may expect that a large part of the capital flows will remain in the country concerned for an indeterminate period of time. By contrast, if a large portion of the variation in the time series is explained by movements in the temporary components, then the capital flows under consideration may be regarded as characterized by low persistence, indicating a higher degree of potential reversibility. [21]

When the maximum likelihood estimate of the variance of an element of the state vector (i.e., σ^2 or one of the diagonal elements of Q) is zero, the model can be re-estimated making the corresponding component deterministic. Also, standard tests of the significance of the component itself can be carried out: if the component concerned is not found to be statistically significantly different from zero, the model may be simplified by eliminating the component from the SSF altogether.

In choosing the most appropriate model for each country and label flow, we relied not only on standard measures such as the coefficient of determination: the fit of alternative models was also compared on the basis of the Akaike information criterion (AIC), equal to $\log(\text{PEV}) + 2(m/T)$, where PEV is the steady-state prediction error variance (Harvey, 1989, pp. 263–270), m represents the number of parameters to be estimated plus the number of nonstationary components, and T is the number of observations. [22]

4.2. Variance ratio tests

The other measure of persistence we employ in this paper is a simple non-parametric test, due originally to Cochrane (1988), generally referred to as the variance ratio test, $z(k)$:

$$z(k) = \frac{1}{k}\frac{\text{Var}(f_{it} - f_{it-k})}{\text{Var}(f_{it} - f_{it-1})} \tag{19}$$

[21] While the irregular component is totally temporary, the AR(1) component displays some degree of positive persistence determined by the size of the damping factor, albeit still mean reverting.

[22] Although the PEV is, in general, the basic measure of goodness of fit, when a choice has to be made among alternative models with different numbers of hyperparameters, it is more appropriate to compare them on the basis of the AIC or alternative information criteria (Harvey, 1989).

where k is a positive integer and Var stands for variance. At one extreme, if movements in the series in question are entirely permanent, then the ratio in Eq. (19) should be equal to unity. If capital flows exhibit mean reversion, however, then the ratio $z(k)$ should be in the range between zero and unity, with a value close to zero indicating a high temporary component.

Cochrane (1988) shows that the Bartlett estimator provides appropriate standard errors for $z(k)$.[23] In small samples, however, both the variance ratios and the Bartlett standard errors may be biased upwards and the asymptotic standard errors may not be a satisfactory approximation of the actual standard errors. Thus, in our empirical work, we adopt the two corrections for small-sample bias suggested by (Cochrane, 1988, pp. 907–910). First, we use the sample mean of the first differences to estimate the drift term at all k rather than estimate a different drift term at each k from the mean of the k-differences. Second, we adopt a degrees of freedom correction, $T/(T-k-1)$, where T is the number of observations.

5. Empirical results [24]

5.1. Unit root tests

As a preliminary exercise, we computed simple augmented Dickey–Fuller unit root tests statistics for each of the five US capital flows examined to Latin America and Asia, both in levels and first differences (not reported but available on request). In every case, we could not reject, at standard significance levels, the null hypothesis that there is a unit root in each of the time series when expressed in levels, while we were always able to reject the hypothesis of nonstationarity of the series in first differences. This therefore provides prima facie evidence of a permanent component in each of the capital flow series. We next employed Kalman filtering techniques to evaluate the relative size of the permanent and temporary components.

5.2. Kalman filter results

In Table 1, we classify the various model specifications which were selected for capital flows to developing countries on the basis of the goodness of fit criteria discussed in Section 4.1. In Tables 2–6, we report the results of estimating the most appropriate structural time series model in SSF by the Kalman filter

[23] Thus, the standard error is consistently estimated as $(4k/3T)^{0.5}\mathrm{Var}(f_{it-k})$.

[24] Throughout our discussion of the empirical results, we employ a nominal significance level of 5% unless explicitly stated otherwise, so that expressions such as ‘statistically significant’, for example, should be read as ‘statistically significantly different from zero at the 5% nominal level of significance’.

Table 1
Structural time series models adopted in modelling capital flows

Model 1: Stochastic level (no slope) + AR(1)
$f_t = \mu_t + \nu_t$
$\mu_t = \mu_{t-1} + \eta_t$
$\nu_t = \rho_\nu \nu_{t-1} + \xi_t \quad |\rho_\nu| < 1$
Model 2: Stochastic level (no slope) + irregular component
$f_t = \mu_t + \epsilon_t$
$\mu_t = \mu_{t-1} + \eta_t$
Model 3: Stochastic level (no slope) + AR(1) + irregular component
$f_t = \mu_t + \nu_t + \epsilon_t$
$\mu_t = \mu_{t-1} + \eta_t$
$\nu_t = \rho_\nu \nu_{t-1} + \xi_t \quad |\rho_\nu| < 1$
Model 4: Stochastic level (fixed slope) + AR(1) + irregular component
$f_t = \mu_t + \nu_t + \epsilon_t$
$\mu_t = \mu_{t-1} + \beta + \eta_t$
$\nu_t = \rho_\nu \nu_{t-1} + \xi_t \quad |\rho_\nu| < 1$
Model 5: Stochastic level (fixed slope) + irregular component
$f_t = \mu_t + \epsilon_t$
$\mu_t = \mu_{t-1} + \beta + \eta_t$
Model 6: Stochastic level (fixed slope) + AR(1)
$f_t = \mu_t + \nu_t$
$\mu_t = \mu_{t-1} + \beta + \eta_t$
$\nu_t = \rho_\nu \nu_{t-1} + \xi_t \quad |\rho_\nu| < 1$

The country subscript, i, is dropped for clarity; notation is the same as in Section 4.1.

maximum likelihood method for both Asian and Latin American capital inflows. [25] In the second and third columns of these tables, we report details of the unobserved components included in the estimated structural time series model. In the fourth column, we report the estimated standard deviations (SD) of the disturbances of the stochastic components included in the state and in parentheses we report the Q-ratios—i.e., the ratios of each estimated SD to the largest SD across components, for each model, which indicates the relative statistical importance of the components. [26] In the fifth column, we report the estimated coefficients of the final state vector (containing information on the values taken by the various components at the end of the sample) and the corresponding estimated root

[25] Note that the convergence achieved by the BFGS numerical optimisation method is always very strong in the sense that the three convergence criteria mentioned in Section 4 are always satisfied using the same tolerance level of 1.0E − 7 for the likelihood kernel, the gradient and the parameters.

[26] In terms of the SSF Eqs. (7)–(10) above, the SDs are the square roots of the estimated diagonal elements of Q; the largest variance (SD) is concentrated out of the likelihood function and, therefore, the Q-ratios are the ratios of each variance (SD) to this variance (SD).

Table 2
Kalman filter results for EF

	Model	Components	Estimated SD of error term (Q-ratios)	Estimated coefficients of final state vector [RMSE]	Estimated AR parameter ρ_ν	R^2	LB(p)
Panel A: Private portfolio EF to Latin America							
Argentina	1	Stc lvl, AR(1)	Lvl: 18.678 (0.194), AR(1): 96.464 (1.000)	Lvl: −1.747 [0.477]**, AR(1): 0.155 [0.030]**	0.116	0.862	0.547
Brazil	1	Stc lvl, AR(1)	Lvl: 1.124 (0.071), AR(1): 15.864 (1.000)	Lvl: 1.532 [0.467]**, AR(1): 0.261 [0.035]**	0.222	0.902	0.437
Chile	2	Stc lvl, Irr	Lvl: 10.736 (0.281), Irr: 38.243 (1.000)	Lvl: 1.714 [0.384]**	–	0.847	0.483
Colombia	1	Stc lvl, AR(1)	Lvl: 2.516 (0.095), AR(1): 26.494 (1.000)	Lvl: 4.156 [1.272]**, AR(1): 0.156 [0.029]**	0.018	0.892	0.764
Ecuador	3	Stc lvl, AR(1), Irr	Lvl: 6.261 (0.143), AR(1): 43.760 (1.000), Irr: 36.940 (0.844)	Lvl: −2.223 [0.798]**, AR(1): −0.164 [0.032]**	0.096	0.804	0.340
Jamaica	1	Stc lvl, AR(1)	Lvl: 3.471 (0.051), AR(1): 67.870 (1.000)	Lvl: −3.359 [1.413]*, AR(1): 0.341 [0.130]**	0.238	0.932	0.943
Mexico	1	Stc lvl, AR(1)	Lvl: 2.545 (0.088), AR(1): 28.953 (1.000)	Lvl: −2.912 [1.285]*, AR(1): 0.362 [0.102]**	0.224	0.893	0.439
Uruguay	3	Stc lvl, AR(1), Irr	Lvl: 2.845 (0.119), AR(1): 23.799 (1.000), Irr: 19.091 (0.802)	Lvl: −2.835 [0.898]**, AR(1): −0.117 [0.031]*	0.048	0.856	0.562
Venezuela	1	Stc lvl, AR(1)	Lvl: 12.103 (0.255), AR(1): 47.428 (1.000)	Lvl: −1.872 [0.664]**, AR(1): 0.127 [0.019]**	0.268	0.822	0.743
Panel B: Private portfolio EF to Asia							
China	4	Stc lvl, Fxd slp, AR(1), Irr	Lvl: 4.577 (0.091), AR(1): 50.009 (1.000), Irr: 0.985 (0.020)	Lvl: 4.963 [0.924]**, Slp: 0.307 [0.043]**, AR(1): −0.456 [0.171]**	0.214	0.838	0.503
India	4	Stc lvl, Fxd slp, AR(1), Irr	Lvl: 1.839 (0.072), AR(1): 25.650 (1.000), Irr: 19.845 (0.774)	Lvl: 6.002 [1.602]**, Slp: 0.601 [0.202]**, AR(1): 0.198 [0.048]**	0.075	0.948	0.683
Indonesia	1	Stc lvl, AR(1)	Lvl: 3.873 (0.065), AR(1): 59.686 (1.000)	Lvl: 3.938 [1.150]**, AR(1): −0.243 [0.045]**	0.059	0.920	0.394
Korea	4	Stc lvl, Fxd slp, AR(1), Irr	Lvl: 5.071 (0.055), AR(1): 92.740 (1.000), Irr: 39.957 (0.431)	Lvl: 1.786 [0.247]**, Slp: 0.778 [0.241]**, AR(1): 0.339 [0.025]**	0.120	0.803	0.756
Malaysia	2	Stc lvl, Irr	Lvl: 10.971 (0.181), Irr: 60.653 (1.000)	Lvl: −4.241 [1.657]*	–	0.792	0.748
Pakistan	2	Stc lvl, Irr	Lvl: 8.951 (0.223), Irr: 40.044 (1.000)	Lvl: −3.118 [1.229]*	–	0.837	0.672
Philippines	2	Stc lvl, Irr	Lvl: 2.997 (0.107), Irr: 27.944 (1.000)	Lvl: 1.250 [0.190]**	–	0.765	0.547
Taiwan	1	Stc lvl, AR(1)	Lvl: 2.420 (0.050), AR(1): 47.958 (1.000)	Lvl: −4.498 [1.466]**, AR(1): 0.395 [0.146]**	0.264	0.829	0.482
Thailand	2	Stc lvl, Irr	Lvl: 3.134 (0.091), Irr: 34.581 (1.000)	Lvl: 3.969 [1.267]**	–	0.801	0.636

The Q-ratio is the ratio of the standard deviation (SD) of each component to the largest SD across components for each model, and is reported in parentheses in the fourth column; in the fifth column, we report the estimated root mean square errors (RMSE) in square brackets, while * (**) indicates statistical significance of the component concerned at the 5% (1%) level. LB(p) is the p-value from executing Ljung–Box test statistics for absence of residual serial correlation which, under the null, are distributed as $\chi^2(p)$ where $p = p_1 - p_2$ and p_1 and p_2 denote the number of lags (= 12) and the number of parameters in the state, respectively. Other abbreviations used are: stc for stochastic, lvl for level, fxd for fixed, slp for slope, irr for irregular.

Table 3
Kalman filter results for BF

	Model	Components	Estimated SD of error term (Q-ratios)	Estimated coefficients of final state vector [RMSE]	Estimated AR parameter ρ_ν	R^2	LB(p)
Panel A: Private portfolio BF to Latin America							
Argentina	2	Stc lvl, Irr	Lvl: 9.569 (0.234), Irr: 40.840 (1.000)	Lvl: 4.210 [1.318]**	–	0.947	0.583
Brazil	4	Stc lvl, Fxd slp, AR(1), Irr	Lvl: 11.445 (0.208), AR(1): 27.056 (0.491), Irr: 55.002 (1.000)	Lvl: 3.688 [1.359]**, Slp: 0.587 [0.024]**, AR(1): −0.327 [0.052]**	0.230	0.956	0.566
Chile	3	Stc lvl, AR(1), Irr	Lvl: 14.144 (0.146), AR(1): 97.108 (1.000), Irr: 75.709 (0.780)	Lvl: 2.331 [0.488]**, AR(1): −0.379 [0.112]**	0.177	0.929	0.741
Colombia	5	Stc lvl, Fxd slp, Irr	Lvl: 3.731 (0.040), Irr: 93.099 (1.000)	Lvl: 3.237 [1.310]*, Slp: 0.925 [0.443]*	–	0.837	0.637
Ecuador	1	Stc lvl, AR(1)	Lvl: 7.728 (0.115), AR(1): 67.220 (1.000)	Lvl: 2.974 [0.436]**, AR(1): 0.359 [0.135]**	0.128	0.902	0.628
Jamaica	6	Stc lvl, Fxd slp, AR(1)	Lvl: 2.484 (0.119), AR(1): 20.868 (1.000)	Lvl: 1.382 [0.418]**, Slp: 0.136 [0.042]**, AR(1): −0.228 [0.054]**	0.085	0.863	0.329
Mexico	4	Stc lvl, Fxd slp, AR(1), Irr	Lvl: 8.693 (0.146), AR(1): 59.691 (1.000), Irr: 42.949 (0.719)	Lvl: 1.508 [0.279]**, Slp: 0.878 [0.266]**, AR(1): 0.367 [0.111]**	0.223	0.877	0.541
Uruguay	2	Stc lvl, Irr	Lvl: 20.410 (0.260), Irr: 78.502 (1.000)	Lvl: 3.935 [1.589]*	–	0.892	0.522
Venezuela	5	Stc lvl, Fxd slp, Irr	Lvl: 1.934 (0.085), Irr: 22.728 (1.000)	Lvl: 3.093 [1.121]**, Slp: 0.761 [0.229]**	–	0.823	0.638
Panel B: Private portfolio BF to Asia							
China	4	Stc lvl, Fxd slp, AR(1), Irr	Lvl: 3.660 (0.046), AR(1): 5.764 (0.073), Irr: 79.360 (1.000)	Lvl: 1.495 [0.217]**, Slp: 0.845 [0.414]*, AR(1): −0.279 [0.099]**	0.270	0.736	0.745
India	3	Stc lvl, AR(1), Irr	Lvl: 4.107 (0.081), AR(1): 50.712 (1.000), Irr: 10.083 (0.199)	Lvl: 5.209 [1.570]**, AR(1): 0.278 [0.081]**	0.184	0.702	0.448
Indonesia	4	Stc lvl, Fxd slp, AR(1), Irr	Lvl: 2.837 (0.032), AR(1): 89.094 (1.000), Irr: 27.529 (0.309)	Lvl: 1.228 [0.230]**, Slp: 0.891 [0.419]*, AR(1): 0.342 [0.142]*	0.230	0.793	0.563
Korea	3	Stc lvl, AR(1), Irr	Lvl: 4.137 (0.216), AR(1): 19.160 (1.000), Irr: 11.310 (0.590)	Lvl: 6.101 [2.154]*, AR(1): −0.247 [0.097]*	0.103	0.839	0.854
Malaysia	1	Stc lvl, AR(1)	Lvl: 9.483 (0.110), AR(1): 85.801 (1.000)	Lvl: 1.249 [0.356]**, AR(1): −0.146 [0.033]**	0.088	0.894	0.496
Pakistan	3	Stc lvl, AR(1), Irr	Lvl: 0.683 (0.039), AR(1): 17.408 (1.000), Irr: 7.524 (0.432)	Lvl: 4.781 [1.636]**, AR(1): 0.172 [0.024]**	0.091	0.884	0.647
Philippines	3	Stc lvl, AR(1), Irr	Lvl: 13.184 (0.175), AR(1): 75.394 (1.000), Irr: 60.162 (0.798)	Lvl: 1.971 [0.346]**, AR(1): 0.384 [0.116]**	0.112	0.931	0.572
Taiwan	3	Stc lvl, AR(1), Irr	Lvl: 2.263 (0.057), AR(1): 19.721 (0.498), Irr: 39.628 (1.000)	Lvl: 4.332 [1.653]**, AR(1): 0.275 [0.069]**	0.225	0.863	0.441
Thailand	1	Stc lvl, AR(1)	Lvl: 6.755 (0.079), AR(1): 85.007 (1.000)	Lvl: 1.044 [0.354]**, AR(1): −0.313 [0.118]**	0.168	0.942	0.746

See notes to Table 2.

Table 4
Kalman filter results for OF

	Model	Components	Estimated SD of error term (Q-ratios)	Estimated coefficients of final state vector [RMSE]	Estimated AR parameter ρ_ν	R^2	LB(p)
Panel A: OF to Latin America							
Argentina	4	Stc lvl, Fxd Slp, AR(1), Irr	Lvl: 11.248 (0.123), AR(1): 91.706 (1.000), Irr: 69.134 (0.754)	Lvl: 2.848 [0.379]**, Slp: 0.553 [0.113]**, AR(1): 0.212 [0.044]**	0.089	0.765	0.349
Brazil	3	Stc lvl, AR(1), Irr	Lvl: 35.120 (0.438), AR(1): 21.647 (0.270), Irr: 80.208 (1.000)	Lvl: 1.798 [0.378]**, AR(1): −0.745 [0.236]**	0.549	0.802	0.428
Chile	3	Stc lvl, AR(1), Irr	Lvl: 6.149 (0.070), AR(1): 88.532 (1.000), Irr: 80.441 (0.909)	Lvl: 1.214 [0.483]*, AR(1): 0.910 [0.255]**	0.765	0.821	0.471
Colombia	4	Stc lvl, Fxd Slp, AR(1), Irr	Lvl: 15.160 (0.186), AR(1): 81.647 (1.000), Irr: 54.395 (0.666)	Lvl: 4.441 [1.578]**, Slp: 0.874 [0.316]**, AR(1): −0.531 [0.165]**	0.301	0.793	0.478
Ecuador	3	Stc lvl, AR(1), Irr	Lvl: 12.810 (0.315), AR(1): 33.351 (0.821), Irr: 40.634 (1.000)	Lvl: 1.236 [0.301]**, AR(1): 0.750 [0.127]**	0.552	0.772	0.501
Jamaica	3	Stc lvl, AR(1), Irr	Lvl: 29.541 (0.463), AR(1): 13.911 (0.218), Irr: 63.860 (1.000)	Lvl: 2.552 [0.391]**, AR(1): −0.811 [0.295]**	0.779	0.915	0.267
Mexico	3	Stc lvl, AR(1), Irr	Lvl: 17.423 (0.553), AR(1): 18.227 (0.578), Irr: 31.508 (1.000)	Lvl: 1.906 [0.757]*, AR(1): 0.553 [0.160]**	0.374	0.837	0.652
Uruguay	3	Stc lvl, AR(1), Irr	Lvl: 6.657 (0.175), AR(1): 38.014 (1.000), Irr: 32.853 (0.864)	Lvl: 4.531 [1.263]**, AR(1): −0.248 [0.032]**	0.100	0.725	0.205
Venezuela	3	Stc lvl, AR(1), Irr	Lvl: 54.921 (0.602), AR(1): 82.907 (0.909), Irr: 91.185 (1.000)	Lvl: 3.379 [1.396]*, AR(1): 0.103 [0.032]**	0.071	0.792	0.667
Panel B: OF to Asia							
China	4	Stc lvl, Fxd Slp, AR(1), Irr	Lvl: 12.496 (0.199), AR(1): 62.712 (1.000), Irr: 36.048 (0.575)	Lvl: 3.090 [0.459]**, Slp: 0.645 [0.127]**, AR(1): 0.491 [0.125]*	0.385	0.736	0.328
India	1	Stc lvl, AR(1)	Lvl: 18.141 (0.410), AR(1): 44.243 (1.000)	Lvl: 1.688 [0.204]**, AR(1): 0.499 [0.104]**	0.328	0.792	0.394
Indonesia	2	Stc lvl, Irr	Lvl: 11.708 (0.605), Irr: 19.351 (1.000), AR(1): 5.283 (0.273)	Lvl: 1.090 [0.296]**, AR(1): 0.561 [0.137]**	0.236	0.934	0.640
Korea	1	Stc lvl, AR(1)	Lvl: 10.095 (0.302), AR(1): 33.460 (1.000)	Lvl: 1.626 [0.482]**, AR(1): 0.555 [0.165]**	0.147	0.874	0.374
Malaysia	3	Stc lvl, AR(1), Irr	Lvl: 11.708 (0.277), AR(1): 42.290 (1.000), Irr: 38.466 (0.910)	Lvl: 3.739 [1.642]*, AR(1): 0.908 [0.287]**	0.605	0.877	0.547
Pakistan	3	Stc lvl, AR(1), Irr	Lvl: 8.512 (0.094), AR(1): 15.102 (0.168), Irr: 90.089 (1.000)	Lvl: 1.176 [0.433]**, AR(1): −0.329 [0.119]**	0.107	0.736	0.743
Philippines	3	Stc lvl, AR(1), Irr	Lvl: 21.669 (0.375), AR(1): 53.182 (0.920), Irr: 57.833 (1.000)	Lvl: 3.171 [1.277]*, AR(1): 0.796 [0.189]**	0.560	0.883	0.912
Taiwan	1	Stc lvl, AR(1)	Lvl: 29.545 (0.300), AR(1): 98.448 (1.000)	Lvl: 1.682 [0.553]**, AR(1): 0.382 [0.076]**	0.208	0.832	0.435
Thailand	3	Stc lvl, AR(1), Irr	Lvl: 6.204 (0.246), AR(1): 25.250 (1.000), Irr: 17.192 (0.681)	Lvl: 2.922 [0.658]**, AR(1): 0.573 [0.194]**	0.426	0.821	0.631

See notes to Table 2.

Table 5
Kalman filter results for BC flows

	Model	Components	Estimated SD of error term (Q-ratios)	Estimated coeffcients of final state vector [RMSE]	Estimated AR parameter ρ_ν	R^2	LB(p)
Panel A: BC flows to Latin America							
Argentina	3	Stc lvl, AR(1), Irr	Lvl: 50.320 (1.000), AR(1): 4.969 (0.099), Irr: 3.944 (0.078)	Lvl: 2.249 [0.816]**, AR(1): 0.846 [0.188]**	0.776	0.969	0.382
Brazil	3	Stc lvl, AR(1), Irr	Lvl: 84.324 (1.000), AR(1): 23.249 (0.276), Irr: 11.875 (0.141)	Lvl: 2.201 [1.044]*, AR(1): 0.752 [0.102]**	0.545	0.936	0.368
Chile	3	Stc lvl, AR(1), Irr	Lvl: 33.360 (1.000), AR(1): 4.073 (0.123), Irr: 2.556 (0.077)	Lvl: 6.652 [2.679]*, AR(1): 0.909 [0.290]**	0.763	0.877	0.387
Colombia	4	Stc lvl, Fxd slp, AR(1), Irr	Lvl: 27.197 (1.000), AR(1): 3.157 (0.116), Irr: 8.937 (0.329)	Lvl: 6.827 [1.843]**, Slp: 0.852 [0.238]**, AR(1): −0.636 [0.177]**	0.541	0.921	0.547
Ecuador	3	Stc lvl, AR(1), Irr	Lvl: 95.115 (1.000), AR(1): 11.940 (0.126), Irr: 12.639 (0.133)	Lvl: 1.302 [0.215]**, AR(1): 0.513 [0.103]**	0.400	0.831	0.631
Jamaica	3	Stc lvl, AR(1), Irr	Lvl: 70.677 (1.000), AR(1): 25.656 (0.363), Irr: 7.127 (0.101)	Lvl: 4.231 [2.008]*, AR(1): −0.294 [0.090]**	0.144	0.934	0.722
Mexico	3	Stc lvl, AR(1), Irr	Lvl: 21.339 (1.000), AR(1): 1.581 (0.074), Irr: 2.575 (0.121)	Lvl: 2.295 [0.758]**, AR(1): 0.617 [0.163]**	0.503	0.882	0.556
Uruguay	3	Stc lvl, AR(1), Irr	Lvl: 84.179 (1.000), AR(1): 3.438 (0.041), Irr: 8.959 (0.106)	Lvl: 4.248 [1.934]*, AR(1): 0.306 [0.142]*	0.179	0.829	0.398
Venezuela	3	Stc lvl, AR(1), Irr	Lvl: 85.721 (1.000), AR(1): 12.867 (0.150), Irr: 6.372 (0.074)	Lvl: 2.487 [0.840]**, AR(1): 0.845 [0.308]**	0.797	0.902	0.379
Panel B: BC flows to Asia							
China	3	Stc lvl, AR(1), Irr	Lvl: 27.927 (1.000), AR(1): 8.507 (0.305), Irr: 4.249 (0.152)	Lvl: 3.025 [1.227]*, AR(1): −0.594 [0.163]**	0.504	0.942	0.453
India	4	Stc lvl, Fxd slp, AR(1), Irr	Lvl: 79.021 (1.000), AR(1): 22.766 (0.288), Irr: 14.916 (0.189)	Lvl: 2.467 [0.604]**, Slp: 0.809 [0.207]**, AR(1): −0.505 [0.092]**	0.348	0.964	0.537
Indonesia	2	Stc lvl, Irr	Lvl: 54.717 (1.000), Irr: 24.402 (0.446)	Lvl: 3.079 [1.342]*	–	0.912	0.511
Korea	5	Stc lvl, Fxd slp, Irr	Lvl: 89.948 (1.000), Irr: 16.088 (0.179)	Lvl: 2.189 [0.876]*, Slp: 0.427 [0.144]**	–	0.884	0.372
Malaysia	6	Stc lvl, Fxd slp, AR(1)	Lvl: 96.414 (1.000), AR(1): 44.950 (0.466)	Lvl: 3.291 [1.098]**, Slp: 0.866 [0.268]**, AR(1): 0.330 [0.121]**	0.247	0.832	0.395
Pakistan	2	Stc lvl, Irr	Lvl: 55.232 (1.000), Irr: 24.288 (0.440)	Lvl: 1.656 [0.329]**	–	0.827	0.693
Philippines	1	Stc lvl, AR(1)	Lvl: 73.398 (1.000), AR(1): 13.469 (0.183)	Lvl: 1.832 [0.486]**, AR(1): −0.711 [0.263]**	0.654	0.891	0.756
Taiwan	2	Stc lvl, Irr	Lvl: 36.404 (1.000), Irr: 12.307 (0.338)	Lvl: 2.863 [1.092]**	–	0.811	0.612
Thailand	2	Stc lvl, Irr	Lvl: 92.287 (1.000), Irr: 28.151 (0.305)	Lvl: 3.092 [1.487]*	–	0.902	0.330

The Q-ratio is the ratio of the standard deviation (SD) of each component to the largest SD across components for each model, and is reported in parentheses in the fourth column; in the fifth column, we report the estimated root mean square errors (RMSE) in square brackets, while * (**) indicates statistical significance of the component concerned at the 5% (1%) level. LB(p) is the p-value from executing Ljung–Box test statistics for absence of residual serial correlation which, under the null, are distributed as $\chi^2(p)$ where $p = p_1 - p_2$ and p_1 and p_2 denote the number of lags (= 4) and the number of parameters in the state, respectively. Other abbreviations used are: stc for stochastic, lvl for level, fxd for fixed, slp for slope, irr for irregular.

Table 6
Kalman filter results for FDI flows

	Model	Components	Estimated SD of error term (Q-ratios)	Estimated coeffcients of final state vector [RMSE]	Estimated AR parameter ρ_ν	R^2	LB(p)
Panel A: FDI flows to Latin America							
Argentina	5	Stc lvl, Fxd slp, Irr	Lvl: 42.681 (1.000), Irr: 0.867 (0.020)	Lvl: 3.741 [0.866]**, Slp: 0.453 [0.083]**	–	0.905	0.329
Brazil	5	Stc lvl, Fxd slp, Irr	Lvl: 69.234 (1.000), Irr: 6.280 (0.091)	Lvl: 2.656 [1.275]**, Slp: 0.567 [0.098]**	–	0.922	0.482
Chile	2	Stc lvl, Irr	Lvl: 25.887 (1.000), Irr: 0.768 (0.030)	Lvl: 3.231 [0.738]**	–	0.836	0.682
Colombia	2	Stc lvl, Irr	Lvl: 45.710 (1.000), Irr: 3.667 (0.080)	Lvl: 3.987 [1.119]**	–	0.881	0.866
Ecuador	2	Stc lvl, Irr	Lvl: 52.569 (1.000), Irr: 4.913 (0.093)	Lvl: 1.951 [0.627]**	–	0.810	0.639
Jamaica	2	Stc lvl, Irr	Lvl: 54.229 (1.000), Irr: 4.708 (0.087)	Lvl: 5.295 [2.067]*	–	0.792	0.684
Mexico	2	Stc lvl, Irr	Lvl: 56.440 (1.000), Irr: 4.163 (0.074)	Lvl: 1.747 [0.595]**	–	0.820	0.547
Uruguay	5	Stc lvl, Fxd slp, Irr	Lvl: 52.792 (1.000), Irr: 3.107 (0.059)	Lvl: 4.645 [2.093]*, Slp: 0.106 [0.024]**	–	0.949	0.736
Venezuela	5	Stc lvl, Fxd slp, Irr	Lvl: 58.189 (1.000), Irr: 3.277 (0.056)	Lvl: 4.729 [1.237]**, Slp: 0.726 [0.159]**	–	0.837	0.648
Panel B: FDI flows to Asia							
China	5	Stc lvl, Fxd slp, Irr	Lvl: 66.880 (1.000), Irr: 2.546 (0.038)	Lvl: 1.183 [0.311]**, Slp: 0.274 [0.101]**	–	0.921	0.439
India	5	Stc lvl, Fxd slp, Irr	Lvl: 26.264 (1.000), Irr: 1.309 (0.043)	Lvl: 4.392 [1.822]*, Slp: 0.939 [0.229]**	–	0.917	0.583
Indonesia	1	Stc lvl, AR(1)	Lvl: 54.807 (1.000), AR(1): 3.027 (0.055)	Lvl: 5.036 [1.255]**, AR(1): − 0.193 [0.091]*	0.097	0.883	0.478
Korea	2	Stc lvl, Irr	Lvl: 70.258 (1.000), Irr: 4.424 (0.063)	Lvl: 3.712 [1.415]**	–	0.901	0.638
Malaysia	2	Stc lvl, Irr	Lvl: 54.926 (1.000), Irr: 1.623 (0.029)	Lvl: 5.601 [1.515]**	–	0.879	0.672
Pakistan	2	Stc lvl, Irr	Lvl: 48.594 (1.000), Irr: 6.928 (0.142)	Lvl: 2.957 [1.335]*	–	0.826	0.711
Philippines	2	Stc lvl, Irr	Lvl: 48.668 (1.000), Irr: 3.920 (0.080)	Lvl: 1.671 [0.274]**	–	0.936	0.620
Taiwan	5	Stc lvl, Fxd slp, Irr	Lvl: 41.362 (1.000), Irr: 1.687 (0.041)	Lvl: 4.256 [1.685]*, Slp: 0.427 [0.162]**	–	0.890	0.467
Thailand	5	Stc lvl, Fxd slp, Irr	Lvl: 46.927 (1.000), Irr: 6.346 (0.135)	Lvl: 3.811 [1.589]*, Slp: 0.958 [0.351]**	–	0.925	0.632

See notes to Table 5.

mean square errors (RMSE); in the last three columns, we report the estimated AR(1) coefficient (the damping factor ρ_ν), which provides evidence on the degree of persistence of the stationary AR(1) component of the model, the coefficient of determination (which can be regarded as quite high for all of the estimated models), and the p-value from Ljung–Box test statistics of the hypothesis of no-serial correlation in the residuals (which always indicates absence of serial correlation).

5.2.1. Bond and equity flows

As Tables 2 and 3 display, for both sets of countries and for both private equity and private bond inflows, the largest variance of the disturbances is always one of the stationary components in the state vector, either the irregular or the AR(1) component. Also, in nine out of 36 cases, the largest estimated parameter is the variance of the disturbance of the irregular component, which has no persistence at all. In the other 27 cases, the AR(1) parameter has the largest variance, which implies some slight degree of persistence. Note, however, that this persistence is also very small, as suggested by the fact that the estimated damping factors in the AR(1) components are always relatively low. Indeed, the half life of shocks affecting private portfolio flows implied by the estimated AR(1) coefficients ranges from 0.172 (hence, less than 1 week) for EF to Colombia to 0.529 (about 2 weeks) for BF to China. [27] Moreover, while the stochastic slope is never found to be statistically significant, the Q-ratios for the stochastic level are very low, suggesting that the contribution of the nonstationary, more persistent component in explaining the variance of EF and BF is extremely low, whereas the temporary component is, by contrast, very large. Nevertheless, the stochastic level is always found to be statistically significantly different from zero at conventional nominal levels of significance, as implied by the estimated coefficients of the final state vector and the corresponding RMSE for the nonstationary stochastic component included in the estimated model. Hence, the results from estimating the unobserved components model for private EF and BF to developing countries suggest that a statistically significant nonstationary component is present in the data, but that this is generally very small in size, contributing very little to explaining variation in the series. That is to say, private portfolio flows to Asian and Latin American countries over the sample period may be regarded as largely temporary and reversible in nature. Also, while their transitory components appear to be on

[27] The half life is the number of periods it would take a shock to the autoregressive component of the capital flow series to be reversed by 50%, and can be estimated as $[(\ln 0.5)/(\ln \rho_\nu)]$. Since ρ_ν is estimated by the method of maximum likelihood which is invariant to transformation, this will in fact be the maximum likelihood estimator of the half life.

average slightly larger in relative size, BF display very much the same statistical properties as EF.

5.2.2. Official flows

Panels A and B of Table 4 show the results from estimating the most appropriate structural time series model for OF to developing countries. On the basis of the estimated *Q*-ratios, the results suggest that OF to both sets of countries contain a dominant temporary component, albeit quite different in size across countries. The stationary AR(1) component is, however, always found to be statistically significantly different from zero, indicating some non-zero persistence —ranging from a half life of 0.286 (slightly more than 1 week) for shocks to OF to Argentina to a maximum half life of 2.775 (about 12 weeks) for OF to Jamaica. While the permanent component is always dominated by the temporary component for each estimated model, the different degree of persistence of OF across countries suggests that in some cases the flows may have been motivated by portfolio adjustment, but for relatively higher-persistence models OF may have responded more strongly to long-term structural factors. As noted above, moreover, in so far as OF may be compensating for reversals in other categories of the capital account, they will be picking up the residual effects of those other flows. Overall, however, our results imply that OF to developing countries—which represent a rather small fraction of total capital flows to emerging markets in the 1990s—were largely temporary in nature over the sample period. [28]

5.2.3. Commercial bank credit

In Panels A and B of Table 5, we report the results from the Kalman filter maximum likelihood estimation of structural time series models for commercial BC flows to the developing countries examined. Consistent with our priors as defined in Section 2, the estimated *Q*-ratios indicate that for both sets of countries the largest variance of the innovations is now always the one relating to the permanent component in the model. Also, the overall relative size of the temporary component of BC flows—i.e., the sum of the *Q*-ratio of the irregular component plus the *Q*-ratio of the AR(1) component—lies between about 15% for BC flows to Uruguay and about 46% for BC flows to Jamaica, displaying significant variation within this range across countries. In addition, for 13 out of 18 cases, the AR(1) parameter is statistically significant and therefore the temporary component has a non-zero degree of persistence, implying a half life varying between 0.358 (about 1 week and a half) for Jamaica and 3.055 (about 13 weeks) for Venezuela.

[28] See World Bank (1997) (pp. 66–71) for further discussion of the nature of OF to developing countries during the 1990s.

Thus, BC flows to developing countries display a permanent component which largely dominates the transitory component in all cases, presumably because they tend to respond significantly to long-term structural forces, such as—for example—a country's creditworthiness ratings, political risk, growth and export performance, macroeconomic stability, and level of indebtedness.

5.2.4. Foreign direct investment

As one might expect, our empirical analysis suggests that the capital-account item with the largest relative permanent component is FDI, as shown by the results in Panels A and B of Table 6. In particular, for both sets of countries not only is the largest variance of the disturbances always the one relating to the permanent component, but the variances of both the irregular component and the AR(1) component—the latter found statistically significant only in one case—are considerably small and, in relative size, lie within the range between 2% for Argentina and about 14% for Pakistan. This clearly is consistent with our prior that FDI flows are largely permanent in nature.

5.3. Variance ratio statistics

Our final exercise was to compute variance ratio statistics corrected for small-sample bias, as suggested by (Cochrane, 1988, pp. 907–910). The results were broadly similar across all countries concerned and so, in order to conserve space, we report in Table 7 results only for one representative Latin American country (Argentina) and one representative Asian country (China). [29]

For BF and EF, the variance ratios reported in Table 7 indicate a fast decline towards zero for both EF and BF, indicating a low degree of persistence. For OF, a slightly slower decline is evident although the overall degree of persistence appears low. Much higher degrees of persistence are indicated for commercial BC, for which the variance ratios are above unity for up to 2 years, and FDI, which has variance ratios above unity for about 3 years.

Thus, the results from the variance ratio tests strongly corroborate the Kalman filter results in that we find the highest indication of permanence for FDI and commercial BC, and the lowest degrees of persistence for EF and BF and OF.

5.4. Summing up the empirical results

Overall, the results reported and discussed in this section suggest that private portfolio flows to developing countries, despite their resilience after the increase in global interest rates in the second half of the 1990s and in the wake of the 1994 Mexican crisis, remain characterized by a statistically significant but very small

[29] Full details of the variance ratio statistics are available from the authors on request.

permanent component, therefore, being potentially susceptible to large reversals. OF also display a relatively large temporary component, albeit smaller than for private portfolio flows and ranging in size across countries. Nevertheless, as one would expect, commercial BC and, to a greater extent, FDI flows contain a relatively very large permanent component. [30]

6. Concluding remarks

The sustained rise in capital flows to developing countries remains one of the salient features of developments in world capital markets during the 1990s. To the extent that this reflects differences in the structural requirements of developed and developing economies, arguments for the potential gains from international capital flows should in principle be little different from the traditional comparative advantage arguments for the potential gains from international trade in goods and services, and indeed may be viewed as representing intertemporal trade. On the other hand, it is now well recognised that capital flows may also have a number of undesirable side effects on recipient economies, requiring the design of appropriate offsetting macroeconomic policy by the authorities of the recipient economies. Gauging the degree of permanence of capital flows then becomes important in the appropriate design of any such policy.

In this paper, we have used maximum likelihood Kalman filtering techniques and non-parametric variance ratio statistics in order to gauge the persistence of the various categories of US capital flows—bond and equity private portfolio flows, commercial bank lending, FDI and OF—to a large group of Asian and Latin American countries over the sample period 1988–1997.

Our empirical results provide strong evidence that there is a statistically significant permanent component in EF and BF to developing countries over the sample period, but that this is very small in size compared to the temporary component. From the policy maker's point of view, this suggests firstly that developing countries should be wary of implementing painful adjustment processes in response to a surge in private portfolio flows that may be reversed in the future and, secondly, that they should guard against any such reversal.

OF to developing countries also appear to contain a relatively large temporary component, albeit to a lesser extent and displaying greater cross-country variation than for private portfolio flows. While OF still remain of some importance

[30] While net private capital flows to East Asia were at record levels in 1996—totalling about US$115 billion—a fall in those flows is expected at some point in 1998, as a consequence of the increased perceived riskiness of lending to the developing countries affected by the recent financial and banking crises. This issue and its implications for the world economy are discussed, for example, in Bank of England (1998).

Table 7
Variance ratio tests

Panel A: Capital flows to Latin America: the case of Argentina

k	EF	BF	OF
1	1.000 (0.107)	1.000 (0.107)	1.000 (0.107)
2	1.227 (0.185)	1.289 (0.195)	1.377 (0.208)
3	0.794 (0.147)	0.832 (0.154)	1.005 (0.186)
6	0.405 (0.106)	0.601 (0.157)	0.596 (0.156)
9	0.298 (0.095)	0.375 (0.120)	0.378 (0.121)
12	0.249 (0.092)	0.291 (0.108)	0.314 (0.116)
18	0.114 (0.052)	0.163 (0.074)	0.243 (0.110)
24	0.081 (0.042)	0.119 (0.062)	0.205 (0.107)
30	0.073 (0.042)	0.092 (0.054)	0.127 (0.074)
36	0.070 (0.045)	0.072 (0.046)	0.080 (0.051)

k	BC	FDI
1	1.000 (0.189)	1.000 (0.189)
2	1.603 (0.430)	1.590 (0.427)
3	1.684 (0.554)	1.681 (0.552)
4	1.530 (0.581)	1.829 (0.694)
6	1.162 (0.540)	1.366 (0.635)
8	1.043 (0.560)	1.096 (0.624)
10	0.951 (0.571)	1.051 (0.631)
12	0.918 (0.604)	1.012 (0.665)

Panel B: Capital flows to Asia: the case of China

k	EF	BF	OF
1	1.000 (0.107)	1.000 (0.107)	1.000 (0.107)
2	1.157 (0.175)	1.179 (0.178)	1.379 (0.208)
3	0.892 (0.165)	0.790 (0.146)	1.145 (0.212)
6	0.494 (0.129)	0.357 (0.093)	0.695 (0.182)
9	0.183 (0.058)	0.236 (0.076)	0.557 (0.178)
12	0.138 (0.051)	0.137 (0.051)	0.432 (0.160)
18	0.069 (0.031)	0.132 (0.060)	0.323 (0.146)
24	0.063 (0.033)	0.098 (0.051)	0.247 (0.129)
30	0.040 (0.023)	0.090 (0.052)	0.179 (0.104)
36	0.038 (0.023)	0.066 (0.042)	0.145 (0.093)

k	BC	FDI
1	1.000 (0.189)	1.000 (0.189)
2	1.522 (0.408)	1.882 (0.505)
3	1.577 (0.518)	1.925 (0.633)
4	1.611 (0.611)	1.758 (0.667)
6	1.202 (0.559)	1.402 (0.634)
8	1.016 (0.545)	1.149 (0.601)
10	0.921 (0.553)	1.021 (0.597)
12	0.680 (0.435)	0.986 (0.631)

especially for low-income developing countries, their general diminution in importance during the 1990s, both in absolute and relative size, implies that this is perhaps a minor concern for policy makers relative to the significant hotness of private portfolio inflows.

Flows of commercial BC and—to a greater extent—FDI display, however, a very large estimated permanent component, suggesting that both of these types of flows are relatively more sensitive to the long-term structural forces relating to a country's economic performance. Also, while commercial BC only played a minor role among capital flows to emerging markets in the 1990s relative to the 1980s, FDI is the capital-account item which has responded most vigorously to the new international environment characterized by increasing liberalization, continuing technological progress and financial innovation (World Bank, 1997). FDI has also a slightly different nature relative to the past: while in the 1970s and 1980s resource extraction and import substitution were the primary motives for FDI flows to developing countries, a large proportion of today's FDI flows is 'efficiency-seeking', associated with competition and rising costs in developed markets, along with falling international transport and communication costs (World Bank, 1997). Today FDI plays a crucial role in increasing the total volume of investment in developing countries, may be more productive than the capital it replaces (even if it substitutes more than augments domestic investment), and is likely to generate knowledge spillover effects that may raise the productivity of existing domestic capital (World Bank, 1997). For all these reasons, the surge in FDI flows to developing countries represents perhaps the most beneficial recent development in the global capital markets.

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Note to Table 7:
EF, BF, OF, BC and FDI are the series defined in the text. The number of observations $T = 120$ for EF, BF and OF, whereas $T = 40$ for BC and FDI; in square brackets we report the Bartlett standard errors, equal to $(4k/3T)^{0.5}\mathrm{Var}(f_{ik})$. k denotes the degree of differencing in computing the variance ratio. Variance ratios and standard errors are computed using the small-sample correction described in the text and suggested by Cochrane (1988) (pp. 907–910).

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