

# International Financial Adjustment

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## Abstract

The paper proposes a unified framework to understand the dynamics of net foreign assets and exchange rate movements. Focusing on the financial account and its determinants, we show that countries' capital gains and losses on net foreign assets constitute a key channel for external adjustment. For example, a depreciation of the domestic currency or a drop in the domestic stock market index improves the sustainability of a country's external position by decreasing the value of its liabilities to foreigners. Our theory implies that deviations from trend of the ratio of net exports to net foreign assets contain information about future portfolio returns and, possibly, future exchange rate changes. Using quarterly data on U.S. gross foreign positions and returns, we find that adjustments in the country's external position occur indeed mostly at short to medium horizons through portfolio revaluations, not through future changes in net exports. We also find evidence of predictability of net foreign asset portfolio returns at horizons between one quarter to three years. These results cast a new light on the sustainability of US current account deficits.

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# 1 Introduction

Understanding the dynamic process of adjustment of a country's external balance is one of the most important questions for international economists. 'To what extent should surplus countries expand; to what extent should deficit countries contract?' asked Mundell (1968). These questions remain as important today as then.

The modern theory which focuses on those issues is the 'intertemporal approach to the current account'. It views the current account balance as the result of forward-looking intertemporal saving decisions by households and investment decisions by firms, under incomplete markets. As Obstfeld (2001)[p11] remarks, 'it provides a conceptual framework appropriate for thinking about the important and interrelated policy issues of external balance, external sustainability, and equilibrium real exchange rates' together with a rigorous, solidly microfounded, analysis of welfare issues for international problems.

This approach has yielded major insights into the current account patterns that followed the two major oil price shocks of the seventies, or the large U.S. fiscal deficits of the early eighties. Yet, in many instances and for most countries, its key empirical predictions are easily rejected by the data. Our paper suggests that this approach falls short of explaining much of the dynamics of the current account because it usually assumes that the only asset traded internationally is a one-period riskfree bond.<sup>1</sup> In reality, international financial markets have become increasingly sophisticated and offer a rich menu of assets (equity, FDI, corporate and government bonds for example). Traditional models therefore ignore a central aspect of the adjustment of countries' external balances, namely, predictable changes in the valuation of foreign assets and liabilities. Fluctuations in the rate of returns of financial assets and in the exchange rate affect in an important way the dynamics of external balances. This link between asset prices, exchange rate and current account dynamics has been ignored in the intertemporal approach to the current account and may explain much of its failure. According to our approach, balance of payments adjustments may occur through this rebalancing of assets and liabilities. Consider the case of the US. It currently has a very negative foreign asset position. The intertemporal budget constraint of the country implies that it will have to reduce this imbalance. The intertemporal approach to the current account suggests that the US will need to run trade surpluses. In this paper, we show that this rebalancing can also take place

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<sup>1</sup>There are exceptions: i) Kray and Ventura (2000) and Ventura (2001) allow for investment in risky foreign capital; ii) the international real business cycle literature usually assumes that markets are complete but this implies that the current account is merely an accounting device and has counterfactual implications; iii) more recently, specific forms of endogeneous market incompleteness have been studied (see for example Kehoe and Perri (2002)).

through a change in the returns on US assets held by foreigners relative to the return on foreign assets held by the US. Importantly, this rebalancing may occur via a depreciation of the dollar. With large gross asset positions, as is the case in the data, a given change in the dollar can transfer large amounts of wealth from the rest of the world to the US and vice versa.<sup>2</sup>

Our framework gives therefore novel insights into the dynamics of adjustment of countries' external account *and* ties the dynamics of the exchange rate to net exports and net foreign assets, thereby reconciling the 'asset market view' and the 'goods market view' of exchange rate determination. It recognizes the central importance of intertemporal budget constraints and transversality conditions for the external adjustment process. But it departs from the literature by allowing for a sophisticated array of internationally traded financial assets. Consequently, this paper shifts the emphasis from the *current* account to the *financial* account and its components.<sup>3</sup> Most importantly, the dynamics of the exchange rate plays a major role in our set up by affecting the differential in rates of returns between assets and liabilities. We show in particular in section 4 that the ratio of net exports to net foreign assets contains significant information about future exchange rate changes, even at relatively short horizons.

In section 2 we briefly review the intertemporal approach to the current account. We then lay down the basic building bloc of our theory of international financial adjustment in section 3. We present the construction of our dataset in section 4 and our empirical results in part 5.

## 2 The Intertemporal Approach to the Current Account

The present value model (PVM) is the most widely used form of the intertemporal approach. Assuming certainty-equivalent preferences and a constant gross world real interest rate  $R$  equal to the inverse of the subjective discount factor, private consumption equals its permanent-income level,

$$C_t = \frac{R-1}{R} N A_t + E_t \tilde{Y}_t - E_t \tilde{I}_t - E_t \tilde{G}_t$$

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<sup>2</sup>For instance, everything else equal, a depreciation of the domestic currency generates a capital gain on foreign assets holdings, which increases the return on the NFA portfolio. Consider the case of the United States. As of December 2001, the country's net foreign asset position was -\$2.31 trillion (or 22.75% of GDP), with assets representing \$6.86 trillion (67.59%) and liabilities \$9.17 trillion (90.34%). All the US liabilities are in dollars whereas approximately 40% of its assets are in foreign currencies. Hence a 20% depreciation of the dollar would represent a transfer of around 5.50 % of GDP from the rest of the world to the US. For comparison, the trade deficit was 4.60% of GDP in 2001.

<sup>3</sup>The financial account was previously called the capital account. Of course, by balance of payment accounting, the current account, capital account, financial account and changes in official reserves sum to zero. But we focus here on which economic factors *drive* the fluctuations in external accounts, and we put the spotlight on financial determinants rather than goods market influences.

where  $\tilde{X}_t \equiv \frac{R-1}{R} \sum_{s=t}^{\infty} R^{-(s-t)} X_s$  represents the annuitized permanent value of any variable  $X$ .<sup>4</sup> This formulation emphasizes that consumption responds to permanent shocks and not to transitory ones. Following Campbell and Shiller (1987), Sheffrin and Woo (1990) show that this gives rise to the following representation for the current account  $CA_t$ ,

$$CA_t = - \sum_{s=t+1}^{\infty} R^{-(s-t)} E_t [\Delta (Y_s - I_s - G_s)] \quad (1)$$

where  $\Delta X_t = X_t - X_{t-1}$  for any variable  $X_t$ .

The PVM emphasizes the quantity-quantity implications of the theory: current account deficits or surpluses forecast future changes in net output,  $Y_t - I_t - G_t$ .

Unlike the Keynesian approach, the intertemporal approach puts less emphasis on intratemporal relative prices and competitiveness, measured by the real exchange rate. Nonetheless, it provides a useful framework for thinking about equilibrium real exchange rates.<sup>5</sup>

Most empirical studies of the intertemporal approach have relied on the PVM and tested whether observed current accounts —the left hand side of equation (1)— equal predicted current accounts —the right hand side.

The results of these tests have not been particularly successful (see Nason and Rogers (2002) for some recent evidence). For most countries and most periods, the testable restrictions imposed by the model have been statistically rejected by the data. Even though predicted current accounts bear some resemblance to observed ones, they appear much less volatile than actual current accounts.

There has also been little systematic investigation of the implications of the intertemporal approach for exchange rates. While some studies have focused on the long run or equilibrium real exchange rate (Lane and Milesi-Ferretti (2002)), few have investigated the implications of the intertemporal approach for exchange rate movements (but see Rogoff (1992) for an important exception). This is perhaps not so surprising given the extensive evidence of low pass-through of exchange rate movements to consumer prices. This low pass-through would hinder both the expenditure switching and the consumption tilting effects that the model highlights (see Engel (2002)).<sup>6</sup>

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<sup>4</sup>The notation is standard.  $NA_t$  is the economy's stock of net foreign claims on the rest of the world at the beginning of period  $t$ .  $Y_t, C_t, I_t$  and  $G_t$  are, respectively, net domestic product, private consumption, net investment and government consumption.  $E_t$  denotes conditional expectations as of time  $t$ .  $R$  appears in the denominator since we measure net foreign assets at the beginning of the period. This is inconsequential.

<sup>5</sup>Real exchange rates have two effects. First, they affect net exports, by affecting the relative demand between exports and imports. This is the traditional 'expenditure-switching' effect that is at the heart of Keynesian models such as the Mundell-Fleming one. Second, real exchange rate changes tilt consumption profiles. This second effect comes via the Euler equation for consumption and the impact of real exchange rate changes on intertemporal relative prices and real interest rates (see Obstfeld and Rogoff (1995)[p1752] for details, and Razin and Svensson (1983)).

<sup>6</sup>Numerous scholars have also extended the simplest framework and incorporated precautionary saving (Gosh and

But more fundamentally, the main reason why the intertemporal approach to the current account has little empirical content is that assuming international investors trade only in a risk-free bond is grossly at odds with reality. In practice, investors have access to a rich menu of financial assets: corporate and sovereign bonds, equity, foreign direct investment and bank loans. While international capital market transactions used to be dominated by bank loans and sovereign bonds, equities and corporate bonds are now major components of these flows.<sup>7</sup>

Modelling a richer menu of assets has three main advantages.

First this helps to explain the volatility of observed current accounts. The net foreign asset (NFA) portfolio of countries contains both assets and liabilities. Therefore, a country's NFA position can be interpreted as a leveraged portfolio, short in domestic assets and long in foreign assets. Its return exhibits more volatility than that of the U.S. one-period ahead risk-free real interest rate, often used as proxy for the world interest rate.

Second, since asset returns exhibit some degree of predictability<sup>8</sup>, so will capital gains or losses on NFA positions. We find that these predictable components contribute significantly to the process of external adjustment.

Third, differences of valuation across asset classes and exchange rate fluctuations will have a direct impact on the external position of a country since individual asset returns are measured in the domestic currency.

### 3 International Financial Adjustment.

This paper lays down the first building block of an intertemporal approach to the financial account: an intertemporal budget constraint and a long run stability condition.

Consider the accumulation identity for net foreign assets between  $t$  and  $t + 1$  :

$$NA_{t+1} \equiv R_{t+1} (NA_t + NX_t) \tag{2}$$

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Ostry (1995)), non-separable utility (Gruber (2000), Bergin and Sheffrin (2000)), barriers to capital mobility (Cole and Obstfeld (1991), Mendoza (1991), Schmitt-Grohe and Uribe (2002)), fiscal shocks (Ahmed and Rogers (1995)), investment dynamics (Glick and Rogoff (1995)) and shocks to the world real interest rate (Neumeier and Perri (2002)). These extensions improve the fit between the models and the data.

<sup>7</sup>See Tesar and Werner (1998), Warnock and Cleaver (2002) and Froot and Tjornhom (2002).

<sup>8</sup>The empirical asset pricing literature has produced a number of financial and macro variables with forecasting power for stock returns and excess stock returns in the U.S. and abroad: the dividend-price and price-earning ratios (Fama and French (1988), Campbell and Shiller (1988)), the detrended T-bill rate (Hodrick (1992)), the term spread—the difference between the 10-year and one-year T-bill yields—and the default spread—the difference between the BAA and AAA corporate bond rates (Fama and French (1989)), the aggregate book-market ratio (Vuolteenaho (2000)), the investment/capital ratio (Cochrane (1991)) and more recently, the aggregate consumption/wealth ratio (Lettau and Ludvigson (2001)).

where  $NX_t$  represents net exports, defined as the difference between exports  $X_t$  and imports  $M_t$ . Net foreign assets  $NA_t$  are defined as the difference between gross foreign assets  $A_t$  and gross foreign liabilities  $L_t$ . The net foreign position increases with net exports and with the return on the net foreign asset portfolio.

$R_{t+1}$  is the realized return on the NFA portfolio in real domestic terms between  $t$  and  $t + 1$  and satisfies:

$$R_{t+1} \equiv w_t^A \left( \tilde{R}_{t+1}^A + \Delta e_{t+1} \right) - w_t^L \tilde{R}_{t+1}^L - \pi_{t+1} \quad (3)$$

where  $\tilde{R}_{t+1}^A$  and  $\tilde{R}_{t+1}^L$  are respectively the gross return *in local currency* on foreign assets and liabilities,  $\Delta e_{t+1}$  is the rate of depreciation of the domestic currency and  $\pi_{t+1}$  is the realized rate of domestic inflation. The possibly time-varying portfolio weights  $w_t^A$  and  $w_t^L$  measure the share of  $NA_t$  invested (long) in gross assets  $A_t$  or (short) in gross liabilities  $L_t$ . They need not be positive or smaller than one.<sup>9</sup>

We work with net exports  $NX_t$  instead of the current account  $CA_t$ . From a national income point of view, the current account records net factor payments, i.e. net dividend payments and net interest income, that are part of the total return  $R_{t+1}$ . If these are the only sources of capital income, then the current account —usually defined— corresponds to changes in net foreign assets, and equation (1) holds. However, in presence of capital gains and exchange rate fluctuations, the National Income and Product Account definition of the current account does not coincide with the change in net foreign assets, evaluated at market value. It is therefore conceptually simpler to work with net exports.

To explore further the implications of (2), we log-linearize following a methodology close to the work of Campbell and Mankiw (1989) and Lettau and Ludvigson (2001) for closed economy budget constraints.<sup>10</sup> Assume first that the ratio of net exports to net foreign assets  $NX_t/NA_t$  is stationary; this will be the case as long as the rate of growth of net foreign assets and the returns on the portfolio of foreign assets are stationary, which should be true in any well-specified model. Define  $\mu_{xa}$  as the steady state value of this ratio:  $\mu_{xa} = \frac{X-M}{A-L}$ . If we assume that the steady state growth rate of net foreign assets  $G$  is smaller than the steady state return on the NFA portfolio  $R$  —a condition necessary to avoid explosive solutions—, equation (2) implies that  $\mu_{xa} = G/R - 1 < 0$ .

We assume also that the ratios  $X_t/A_t$ ,  $M_t/A_t$  and  $L_t/A_t$  are stationary and such that  $(X - M) / A \neq$

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<sup>9</sup>Accumulation equation (2) implies that net foreign assets are measured at the beginning of the period. This timing assumption is innocuous. One could instead define  $\widetilde{NA}_t$  as the stock of net foreign assets at the end of period  $t - 1$ , i.e.  $NA_t = R_t \widetilde{NA}_t$ . The accumulation equation becomes:  $\widetilde{NA}_{t+1} \equiv R_t \widetilde{NA}_t + NX_t$ .

<sup>10</sup>In what follows, log variables (or linear combinations of log variables) will be denoted by lower case letters.

0 and  $L/A \neq 1$ .<sup>11</sup> Dividing (2) through by net foreign assets (assuming  $L_t \neq A_t$  almost everywhere), we obtain:

$$\begin{aligned} \frac{NA_{t+1}}{NA_t} &= R_{t+1} \left( 1 + \frac{NX_t}{NA_t} \right) \\ \frac{A_{t+1}/A_t - L_{t+1}/A_t}{1 - L_t/A_t} &= R_{t+1} \left( 1 + \frac{X_t/A_t - M_t/A_t}{1 - L_t/A_t} \right) \end{aligned}$$

Log-linearizing around the stationary ratios, defining  $nx_t \equiv \frac{X/A}{X/A-M/A}x_t - \frac{M/A}{X/A-M/A}m_t$  and  $na_t \equiv \frac{1}{1-L/A}a_t - \frac{L/A}{1-L/A}l_t$ , we obtain:

$$\Delta na_{t+1} = r_{t+1} + \left( 1 - \frac{1}{\rho} \right) (nx_t - na_t) \quad (4)$$

where  $\rho \equiv 1 + \mu_{xa} < 1$ ,  $na_t \equiv \mu_a a_t - \mu_l l_t$  and  $nx_t \equiv \mu_x x_t - \mu_m m_t$ .<sup>12</sup> Equation (4) is the linearized counterpart to equation (2) and carries the same interpretation. It can be solved forward to give, after imposing a transversality condition and taking expectations:<sup>13</sup>

$$nx_t - na_t = \sum_{j=1}^{+\infty} \rho^j \text{E}_t [r_{t+j} - \Delta nx_{t+j}] \quad (5)$$

This equation plays a central role in our approach. To gain some intuition, consider again the case of the U.S. It currently runs a substantial trade deficit and has a net foreign liability. Assume that the US will maintain a negative foreign position in steady state ( $1 - L/A < 0$ ), so that it will have to run a trade surplus in steady state ( $X/A - M/A > 0$ ). Given our definitions, this implies that  $nx_t$  is negative, increases with exports, while  $na_t$  is positive and increases with liabilities, so that  $nx_t - na_t$  is large and negative and  $r_{t+j}$  measures returns on U.S. net foreign liabilities. If the return on net foreign assets  $r_{t+j}$  is constant, equation (5) posits that the adjustment *must* come through future improvements in net exports ( $\Delta nx_{t+j} > 0$ ), that may require a real depreciation of the dollar. This is the standard implication of the intertemporal approach to the current account.<sup>14</sup> We emphasize instead that the adjustment *may* come from low predictable excess returns on U.S. net

<sup>11</sup>We verify this assumption empirically. See in section 5. Observe that since  $A$  and  $L$  are composed of imperfectly substitutable assets, it is reasonable to assume that their ratio is stationary in the long run. While equal changes in  $A$  and  $L$  leave net foreign positions unchanged, they affect a country's exposure to asset price and exchange rate movements. The last restriction ensures that the shares of exports, imports, assets and liabilities in net exports and net foreign assets respectively are well defined.

<sup>12</sup>The weights  $\mu_x$  and  $\mu_m$  ( $\mu_a$  and  $\mu_l$ ) represent the steady state shares of exports and imports (assets and liabilities) in net exports (net assets) and are well defined under the assumption that  $X/A$ ,  $M/A$  and  $L/A$  are stationary. With our convention  $\mu_x, \mu_m > 0$  and  $\mu_a, \mu_l < 0$  for a country (like the US) with a long run trade surplus and negative net foreign asset position. For details on the loglinearization see appendix A.

<sup>13</sup>The transversality condition is  $\lim_{j \rightarrow \infty} \rho^j (nx_{t+j} - na_{t+j}) = 0$ .

<sup>14</sup>See Obstfeld and Rogoff (2001) for an analysis along these lines.

liabilities to foreigners,  $r_{t+j}$ , through a combination of low returns on foreign-owned U.S. assets and high returns on U.S.-owned foreign assets. Importantly, according to equation (3) such predictable returns can occur via a depreciation of the dollar. While such a depreciation is certainly consistent with an improvement in future net exports, the important point is that it operates through an entirely different -and until now unexplored- channel: a wealth transfer from foreigners to US residents.

It is important to emphasize that equation (5) is an identity: it holds in expectations, but also along every sample path. Accordingly, one cannot hope to ‘test’ it.<sup>15</sup> Yet it presents several advantages that guide our empirical strategy.

First, this identity still contains useful information: *the ratio of net foreign assets to net exports can move only if it forecasts either future returns on net foreign assets, or future net export growth.* We propose to evaluate empirically the relative importance of these two factors.

Second, as Lettau and Ludvigson (2001) show for the consumption wealth ratio, equation (5) also demonstrates an important property: under the maintained assumption that net foreign asset returns and net export growth are stationary, (5) implies that the left hand side is also covariance-stationary. Given our definitions, a linear combination of exports, imports, gross assets and liabilities must be cointegrated.<sup>16</sup> This is important since data on gross assets and liabilities are likely to be measured with error. Cointegration techniques provide an efficient method to recover deviations from trend as long as the measurement errors are stationary.

Third, since our modeling relies only on the intertemporal budget constraint and a long run stability condition, it is consistent with most behavioral models. We see this as a strength of our approach, since it nests any model that incorporates an intertemporal budget constraint. But this also limits the interpretation of the evidence. For instance, our analysis is silent as to the horizon at which the adjustment should take place, or through which mechanism.

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<sup>15</sup>Technically, only equation (2) is an identity. Equation (5) holds under the additional assumptions that (a) the transversality condition holds and (b) expectations are formed rationally.

<sup>16</sup>This is perfectly consistent with our results of section 5 where we find that the three series  $X_t/A_t$ ,  $M_t/A_t$  and  $L_t/A_t$  are stationary. In fact,  $nx_t - na_t$  is simply a linear combination of the three co-integration vectors that link  $x_t$ ,  $m_t$ ,  $a_t$  and  $l_t$ .



## 4 Net foreign assets, net exports, asset returns and exchange rates.

### 4.1 Data.

The empirical counterpart of our theory requires computing the return on global country portfolios. We use quarterly U.S. data on assets and liabilities vis-a-vis the rest of the world<sup>17</sup>.

#### 4.1.1 Positions.

Following official classifications, we split the U.S. net foreign portfolio into four categories: debt, equity, Foreign Direct Investment (FDI) and other. The ‘other’ category includes mostly bank loans and trade credits. We used data from the Flow of Funds Accounts for gross asset and liability positions. These data have the advantage of being quarterly and of starting in 1952. The drawback is that only equity is recorded at market value. Debt, FDI and ‘other’ claims are recorded at acquisition value.

For robustness purposes we also replicated our results using the Bureau of Economic Analysis/International Monetary Fund International Investment Positions data on gross foreign asset positions. These data are arguably more precise since they record gross asset positions at market value, but they are yearly and start in 1980 only.<sup>18</sup> We built quarterly positions for the post-1980 period based on value-adjusted flows to match the end-of-year stocks. For the pre-1980 period (until 1973) we cumulated value-adjusted flows. Since measurement errors cumulate, we feel less confident in our BEA based measure before 1980.

#### 4.1.2 Returns.

We use MSCI stock indexes in dollars for valuations of equity and FDI. For the debt component of the portfolio, we use 3-month interest rates for the short term component and annual returns on 7-10 year bonds for the long term component.<sup>19</sup> For the ‘other’ category, which includes mostly short-term credits, we use the 3-month interest rates. Our constructed series of net foreign asset position for the US is shown in Figure 1, relative to household net worth. We see a strong deterioration of the U.S. net foreign asset position after 1982.

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<sup>17</sup>The Lane and Milesi-Ferretti (2001) data set includes annual data since 1973. Unfortunately this does not offer enough datapoints for our analysis.

<sup>18</sup>See Hooker and Wilson (1989) for a detailed comparison of the Flow of Funds and BEA data.

<sup>19</sup>We use the Treasury report on US holdings of foreign Long-Term securities (2000) to construct a return on foreign bond as a weighted average of individual countries bond returns. We use yields for the following countries, with the weights in parenthesis: Canada (45.5%), United Kingdom (23.1%), Germany (18.5%) and Japan (12.9%). These countries represent 42.9% of U.S. long term foreign bond holdings. Data availability limits extending the sample further. We also assume, based on the TIC data, that the split between short and long returns is 40/60.

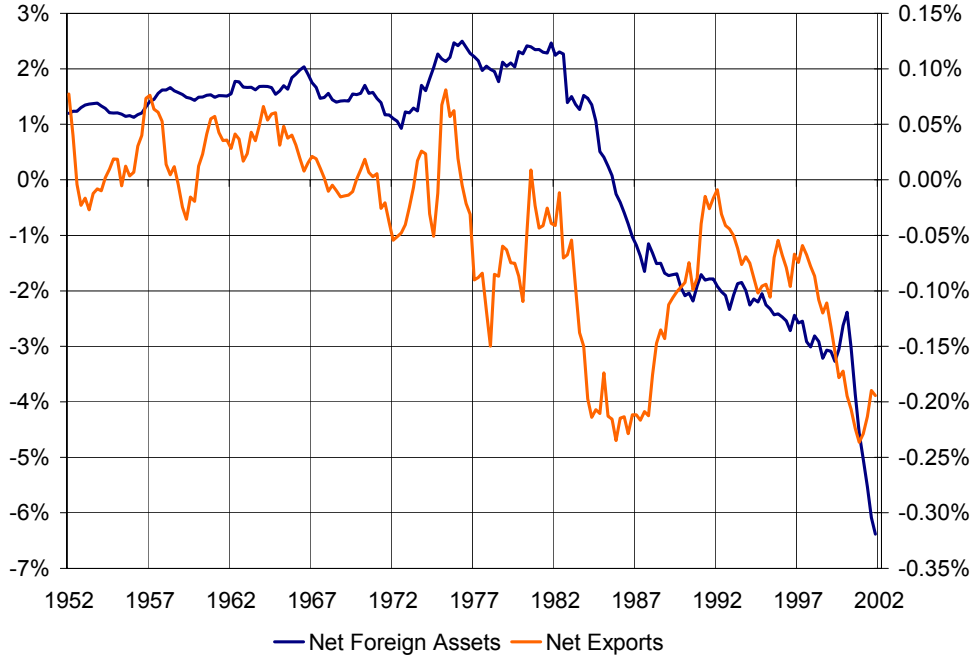


Figure 1: Net Foreign Assets (left scale) and Net Exports (right scale) (% of Household Wealth), U.S., 1952-2001. Source: Flow of Funds and NIPA.

## 5 Empirical results.

The previous section showed that (a) (log) exports, imports, gross foreign assets and liabilities should be cointegrated; and (b) the deviation from trend should contain information about future net export growth or future net foreign asset returns. Our empirical implementation proceeded therefore in two steps. First we tested for unit roots in exports, imports, assets and liabilities. We then tested for the stationarity of the three series  $X_t/A_t$ ,  $M_t/A_t$  and  $L_t/A_t$  using Johansen cointegration tests. Second, having found the existence of three cointegrating relations, we estimate the cointegrated vector linking our four variables of interest and explore its forecasting properties. As noted above, given the presence of measurement error in the gross position data, it is more efficient to estimate the cointegrating vector using dynamic OLS rather than using the weights derived in the loglinearization.

### 5.1 The asset channel of external adjustment

Our methodology is linked to Lettau and Ludvigson (2001). Using Phillips-Ouliaris tests (not reported here for the sake of space), we could not reject unit roots in each of our four series (exports, imports, assets and liabilities). Performing Johansen cointegration tests (also unreported) we found stationarity for the series  $X_t/A_t$ ,  $M_t/A_t$  and  $L_t/A_t$ .

Following Stock and Watson (1993) we then estimated the cointegrating vector using dynamic least squares. We find the following vector:  $x - 0.796154 * m + 0.208019 * a - 0.232948 * l$ .

The estimated co-integration relationship has therefore the correct signs (they are opposite on imports and exports and on assets and liabilities) with a unit coefficient on (log) exports. Econometric theory tells us that the cointegrating residual *must* forecast the growth rate of at least one of our four series: exports, imports, gross assets or gross liabilities, provided enough lags are included in the regression. This is the Granger Representation Theorem and it is equivalent to saying that there is an error-correction representation. When we test for which variable(s) the cointegration residual predicts, the results are very clear-cut (see Table 1).<sup>20</sup>

The cointegration residual has *no* forecasting power for exports or imports at a one quarter horizon. But it *does* predict foreign assets and liabilities growth rates one quarter ahead. This result is consistent with our proposed re-interpretation of the external adjustment mechanism. It emphasizes that future gross assets and liabilities, not exports or imports, adjust to bring the ratio back to equilibrium.

The next logical step is to find out which specific components of foreign assets and liabilities (if any) the residual predicts.

We present evidence pertaining to this question in panel 1 of Table 2. We regressed the dollar stock return differential between the U.S. and the rest of the world ( $R_{US} - R^* - \Delta e$ ), at the quarterly frequency, on our lagged cointegration residual  $\widetilde{nx}a_{t-1}$ .<sup>21</sup> According to equation (5), an improvement in net exports relative to net foreign assets should be consistent with a lower return on the NFA portfolio, and hence, a higher return on US assets relative to foreign assets.

Indeed, we find that our variable predicts excess equity returns one quarter ahead with the correct sign.<sup>22</sup> We obtain an  $R^2$  of 0.08.<sup>23</sup> This result is rather encouraging. To check its robustness, we add the domestic and foreign dividend price ratios  $d - p$  and  $d^* - p^*$ , variables known to predict returns, and show (still panel 1) that they do not alter our result.<sup>24</sup>

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<sup>20</sup>Here as for the remaining part of the empirical section we present results based on the Flow of Funds data set. The results are similar using the BEA data set, and are omitted in the sake of preserving space.

<sup>21</sup>Equation (3) indicates that we should use real returns. The results are equivalent if we deflate excess returns by the US inflation rate.

<sup>22</sup>One might wonder why we chose the stock return differential and not the differential in total returns (including other assets). The answer is that it does not matter: the total return on the US portfolio is very highly correlated with the return on the equity part of the portfolio.

<sup>23</sup>This is comparable to the findings of the empirical finance literature. For instance, Lettau and Ludvigson (2001) find a  $R^2$  of 0.09 at a one-quarter horizon.

<sup>24</sup>We obtained the dividend-price variables from John Campbell. We observe that the dividend-price ratio is not significant, even on its own. Lettau and Ludvigson (2001) show that the dividend-price ratio contains information

Dependent variable	Equation			
	$\Delta x_t$	$\Delta m_t$	$\Delta a_t$	$\Delta l_t$
$\sum \Delta x_{t-i}, i = 1, 2$	0.040 (0.115)	-0.174 (0.107)	-0.022 (0.068)	-0.024 (0.082)
$\sum \Delta m_{t-i}, i = 1, 2$	0.080 (0.122)	0.122 (0.114)	0.078 (0.072)	-0.031 (0.088)
$\sum \Delta a_{t-i}, i = 1, 2$	<b>0.404</b> (0.199)	<b>0.455</b> (0.186)	-0.027 (0.118)	-0.134 (0.143)
$\sum \Delta l_{t-i}, i = 1, 2$	0.05 (0.156)	0.095 (0.145)	0.139 (0.09)	0.145 (0.114)
$\widetilde{nx}a_{t-1}$	-0.003 (0.006)	-0.004 (0.005)	<b>0.053</b> (0.022)	<b>-0.061</b> (0.027)
$\bar{R}^2$	0.04	0.07	0.05	0.07

Table 1: Estimates from a Cointegrated VAR. Sample: Flows of Funds, 1952:1-2001:4

## 5.2 Exchange rate predictability

We now decompose the differential in equity returns into the U.S. return part,  $R_t^{US}$ , and the rest of the world return part,  $R_t^* + \Delta e_t$  (see panels 2 and 3). The data clearly indicate that our cointegrating residual does *not* predict the U.S. return part (see panel 2), whether it is the only variable in the regression, or when we include the U.S. dividend price ratio, or the variable denoted by  $\widetilde{cay}$  (Lettau and Ludvigson's (2001) cointegration residual linked to deviations from trend of the consumption-wealth ratio).

What our cointegration residual does forecast, however, is the rest of the world equity return (panel 3) and more precisely changes in the US exchange rate (panel 4).<sup>25</sup> We forecast exchange rate changes one quarter ahead with an  $R^2$  of 0.07. When we add interest rate differentials as well (and confirm once more that uncovered interest parity is violated since the sign on the relevant coefficients is negative instead of positive) the  $R^2$  climbs to 0.10 and our variable is not affected. In figure 2, we plot our cointegrating residual  $\widetilde{nx}a$  and (the inverse of) the exchange rate depreciation. Our variable is a bit smoother than the exchange rate, but it seems to track remarkably well the currency variations (even the sharp appreciation of the dollar in the 80s) at the quarterly frequency and lower.

Again we believe that the results we have here are strongly indicative of the promise of our ap-

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about long run returns (typically 4 years and beyond).

<sup>25</sup>We use a US effective exchange rate based on financial weights. Note that panel 4 is estimated over the floating rate period only.

Panel 1: $R_t^{US} - R_t^* - \Delta e_t$					Panel 2: $R_t^{US}$					
lag	$\widetilde{nx\bar{a}}$	$d - p$	$d^* - p^*$	$\bar{R}^2$	lag	$\widetilde{nx\bar{a}}$	$d - p$	$cay$	$i^{US} - i^*$	$\bar{R}^2$
	<b>0.448</b>			0.08		0.121				0.00
	(0.118)					(0.133)				
0.025				0.00	0.05					0.00
(0.089)					(0.089)					
-0.085	<b>0.501</b>			0.10	0.043	0.107				0.00
(0.089)	(0.126)				(0.090)	(0.136)				
		0.424	-1.76	0.00			1.193			0.00
		(5.22)	(4.25)				(3.157)			
	<b>0.581</b>	3.19	-0.65	0.11	0.260	2.894				0.01
	(0.144)	(4.94)	(4.00)		(0.153)	(3.287)				
							<b>5.689</b>			0.04
							(2.271)			
Panel 3: $R_t^* + \Delta e_t$					Panel 4: $\Delta e_t$ (1973:1-2001:4)					
	<b>-0.326</b>			0.02		<b>-0.128</b>				0.07
	(0.158)					(0.040)				
-0.057				0.00	0.075					0.00
(0.089)					(0.095)					
-0.090	<b>-0.376</b>			0.03	0.014	<b>-0.126</b>				0.07
(0.088)	(0.162)				(0.093)	(0.042)				
			0.617	0.00					-0.548	0.02
			(3.071)						(0.311)	
	-0.287		-1.06	0.02		<b>-0.136</b>			<b>-0.593</b>	0.10
	(0.186)		(3.24)			(0.039)			(0.297)	

Table 2: Forecasting Quarterly Returns. Source: Flow of Funds, 1952:1-2001:4. Regressors lagged one period.

proach. Traditional models of exchange rate determination fare particularly badly at the quarterly-yearly frequencies and it seems that our theory, which emphasizes a different set of fundamental variables, is paying off. Our cointegrating residual variable enters with the predicted sign and is strongly significant: a large ratio of net exports to net foreign assets predicts a subsequent appreciation of the dollar, which generates a capital loss on foreign assets.

### 5.3 Long horizon forecasts

There are immediate extensions of the above results. First, we investigate the forecasting ability of our variable  $\widetilde{nx\bar{a}}$  at various time horizons, beyond a quarter. Nothing in the linearized intertemporal budget equation we have been using is telling us that the interesting horizon to consider is one-quarter ahead. Looking at exchange rate variations at longer horizons may even give us better results since the exchange rate variable will be smoother. Table 3 reports in-sample predictability of results at longer horizons for the equity return differential as well as the rate of depreciation of the dollar. Our

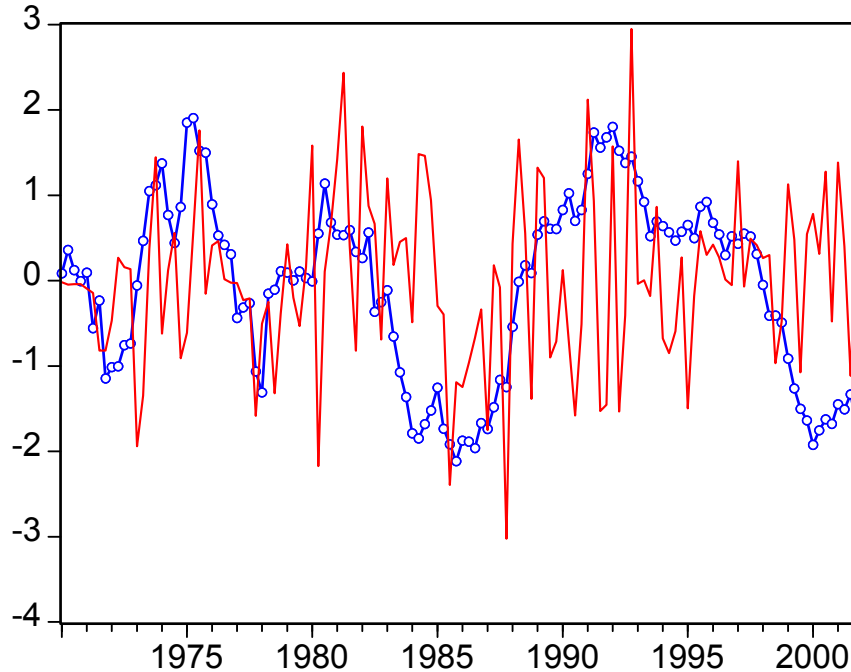


Figure 2: Depreciation Rate (inverted scale) (-) and Net Exports/Net Foreign Assets (deviation from trend) (o). Source: Flow of Funds and NIPA. Data is normalized by standard deviation.

variable has substantial predictive power for future differential equity returns and rate of depreciation of the currency. The predictive power is increasing with the horizon, up to 12 quarters.

#### 5.4 Out-of-sample forecast

We perform out-of-sample forecasts by rolling estimation of our model and comparing its performance to simple forecasting models. This will enable us to revisit the classic Meese and Rogoff (1983) result. These authors showed that none of the existing exchange rate models could outperform a random walk at short to medium term horizons (we are working exactly at those same horizons) in out-of-sample forecasts. This result has never been overturned so far.<sup>26</sup> Table 4 compares results on the out-of-sample forecasting performance on three nested models of the dollar stock return differential between the US and the rest of the world at different horizons. Each model is first estimated on the sub-sample 1973:1 1987:1. We then recursively estimate the parameters of the model, adding

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<sup>26</sup>Interestingly, some recent work by Kilian and Inoue (2002) notes that because out-of-sample tests lose power due to the sample splitting, they may fail to detect predictability where in-sample test would find it. According to these authors, both in-sample and out-of-sample tests are valid, provided that correct critical values are used.

	Forecast Horizon						
	1	2	3	4	8	12	24
Equity Return Differential							
$\widetilde{nx}a_{t-1}$	<b>0.45</b>	<b>0.10</b>	<b>1.44</b>	<b>1.91</b>	<b>3.37</b>	<b>4.68</b>	<b>7.32</b>
$t_{NW}$	(3.42)	(3.41)	(3.54)	(3.69)	(3.55)	(3.53)	(3.34)
$\bar{R}^2$	[0.08]	[0.19]	[0.26]	[0.30]	[0.35]	[0.36]	[0.28]
Rate of depreciation							
$\widetilde{nx}a_{t-1}$	<b>-0.13</b>	<b>-0.24</b>	<b>-0.36</b>	<b>-0.47</b>	<b>-0.90</b>	<b>-1.15</b>	<b>-1.02</b>
$t_{NW}$	(3.11)	(3.07)	(3.34)	(3.56)	(4.01)	(4.02)	(3.04)
$\bar{R}^2$	[0.07]	[0.13]	[0.21]	[0.25]	[0.39]	[0.41]	[0.23]

Table 3: Long-horizon Regressions. Sample: Flows of Funds, 1952:1-2001:4. Newey-West corrected t-statistics in parenthesis and adjusted  $R^2$  in brackets.

one quarter at a time and calculating series of  $k$ -period ahead forecasts ( $k = 1, 2, 3, 4$ ).<sup>27</sup> The results indicate that our model improves significantly on the random walk, at up to 4 quarters.

## 5.5 Variance Decomposition

We decompose the net export to net foreign asset ratio into its return and net export growth components. The first decomposition follows Cochrane (1992) and uses the unconditional form of equation (5) to express the variance of  $\widetilde{nx}a$  as:

$$\text{var}(\widetilde{nx}a_t) = \sum_{j=1}^{+\infty} \rho^j \text{cov}(\widetilde{nx}a_t, r_{t+j}) - \sum_{j=1}^{+\infty} \rho^j \text{cov}(\widetilde{nx}a_t, \Delta nx_{t+j})$$

for various values of  $\rho$ . Each sum on the right hand side can be approximated by truncation over the sample period. For values of  $\rho$  close to 1, this decomposition expresses the share of the variance of  $\widetilde{nx}a$  explained by returns (net exports) as the coefficient from a regression of long portfolio returns (long run export growth) on current  $\widetilde{nx}a$ . Decomposing the net asset portfolio return into its components according to equation (3), we can further evaluate the importance of exchange rate fluctuations versus local currency equity returns.

Second, we evaluate directly the importance of currency fluctuations for the ratio of net exports to net foreign assets. Suppose that exchange rate movements explain predictable net portfolio returns

<sup>27</sup>The analysis uses the cointegrating vector  $\widetilde{nx}a$  estimated on the whole sample. This is justified since the estimated parameters of the vector are superconsistent.

Nested Model	$\frac{MSEu}{MSEr}$	ENC-NEW	Nested Model	$\frac{MSEu}{MSEr}$	ENC-NEW
Horizon: 1 quarter			Horizon: 2 quarters		
$\widetilde{nxa}$ vs AR(1)	0.984	7.27**	$\widetilde{nxa}$ vs AR(1)	0.976	14.04**
$\widetilde{nxa}$ vs $\Delta \frac{d}{p}$	0.889	10.93**	$\widetilde{nxa}$ vs $\Delta \frac{d}{p}$	0.790	27.78**
$\widetilde{nxa}$ vs AR(1), $\Delta \frac{d}{p}$	0.935	11.52**	$\widetilde{nxa}$ vs AR(1), $\Delta \frac{d}{p}$	0.787	26.77**
Horizon: 3 quarters			Horizon: 4 quarters		
$\widetilde{nxa}$ vs AR(1)	0.900	21.79**	$\widetilde{nxa}$ vs AR(1)	0.853	28.30**
$\widetilde{nxa}$ vs $\Delta \frac{d}{p}$	0.623	43.01**	$\widetilde{nxa}$ vs $\Delta \frac{d}{p}$	0.572	49.93**
$\widetilde{nxa}$ vs AR(1), $\Delta \frac{d}{p}$	0.668	42.52**	$\widetilde{nxa}$ vs AR(1), $\Delta \frac{d}{p}$	0.635	54.71**

Table 4: Out of Sample Tests.  $MSEu$  is the mean-squared forecasting error for an unrestricted model that includes the lagged dependent variable and lagged  $nxa$  (model 1); lagged  $\Delta d/p$  and lagged  $nxa$  (model 2); the lagged dependent variable, lagged  $\Delta d/p$  and lagged  $nxa$  (model 3).  $MSEr$  is the mean-squared error for the restricted models which include the same variables as above but do not include lagged  $nxa$ .  $\Delta d/p$  is the difference between the US and the rest of the world dividend price ratio. ENC-NEW is the modified Harvey et al. (1998) statistic, as proposed by Clark and McCracken (1999). Under the null, the restricted model encompasses the unrestricted one. Sample: Flows of Funds, 1973:1-2001:4. \*\* significant at the one percent level.

(i.e.  $E_t r_{t+1} = \alpha + \beta E_t \Delta e_{t+1}$ ). Then, equation (5) imposes the following restriction:<sup>28</sup>

$$\begin{aligned} \widetilde{nxa}_t &= \sum_{j=1}^{+\infty} \rho^j E_t [\beta \Delta e_{t+j} - \Delta nx_{t+j}] \equiv \widetilde{nxa}_t^* \\ &\equiv \widetilde{nxa}_t^{*\Delta e} + \widetilde{nxa}_t^{*\Delta nx} \end{aligned} \quad (6)$$

$\widetilde{nxa}_t^{*\Delta e}$  is the component of  $\widetilde{nxa}_t^*$  that forecasts future currency movements, while  $\widetilde{nxa}_t^{*\Delta nx}$  is the component that forecasts future change in net exports. We propose to follow Campbell and Shiller (1988) and construct empirical estimates of  $\widetilde{nxa}_t^{*\Delta e}$  and  $\widetilde{nxa}_t^{*\Delta nx}$  using a VAR formulation. Specifically consider the VAR(p) representation for the vector  $(\Delta e_{t+1}, \Delta nx_{t+1}, \widetilde{nxa}_t)'$ . Appropriately stacked, this VAR has a first order companion representation:  $\mathbf{z}_{t+1} = \mathbf{A} \mathbf{z}_t + \boldsymbol{\epsilon}_{t+1}$ . Equation (6) implies that we can construct  $\widetilde{nxa}_t^{*\Delta e}$  and  $\widetilde{nxa}_t^{*\Delta nx}$  as:

$$\begin{aligned} \widetilde{nxa}_t^{*\Delta e} &= \beta \mathbf{e}'_{\Delta e} \mathbf{A} (\mathbf{I} - \rho \mathbf{A})^{-1} \mathbf{z}_t \\ \widetilde{nxa}_t^{*\Delta nx} &= -\mathbf{e}'_{\Delta nx} \mathbf{A} (\mathbf{I} - \rho \mathbf{A})^{-1} \mathbf{z}_t \end{aligned}$$

where  $\mathbf{e}'_{\Delta e}$  ( $\mathbf{e}'_{\Delta nx}$ ) defines a vector that ‘picks’  $\Delta e_t$  ( $\Delta nx_t$ ). In addition, the testable restriction  $\mathbf{e}'_{nxa} (\mathbf{I} - \rho \mathbf{A}) = (\beta \mathbf{e}'_{\Delta e} - \mathbf{e}'_{\Delta nx}) \mathbf{A}$  should be satisfied if the model is not rejected by the data.<sup>29</sup>

[TO BE CONTINUED]

<sup>28</sup>Up to a constant.

<sup>29</sup>See Campbell and Shiller (1988) for an application to U.S. stock prices.



## 6 Conclusion

This paper presents a general framework to jointly model the financial account and the exchange rate. We used accounting identities and a minimal set of assumptions to derive our results. In a companion paper, we specify our model further by nesting behavioral assumptions into the current framework. Thereby we are aiming at developing a comprehensive ‘Intertemporal Approach to the Financial Account’ where the dynamics of valuations of net foreign assets take center stage in the adjustment mechanism and international portfolio allocations result from optimizing behavior of economic agents. The behavioral models nested within our current framework should of course be consistent with the patterns uncovered in our data. We found that large US foreign liabilities (or low net exports) were associated with net future capital losses on US assets relative to foreign assets, in part via a depreciation of the dollar. A natural question is why the rest of the world would hold US assets, knowing that these assets return will underperform. This is a major challenge for a successful modelling of the international adjustment mechanism, and one that has not been addressed so far.<sup>30</sup> In our international context, the portfolio balance theory<sup>31</sup>, which emphasizes market incompleteness and imperfect substitutability of assets, seems well suited to formalize these effects (see Gourinchas and Rey 2003).

Our framework has already yielded interesting results regarding the predictability of nominal exchange rates as well as the role of asset revaluation in the external adjustment mechanism. Our approach can also help address three other important issues.

First, it provides a new perspective on the issue of current account sustainability. The typical approach emphasizes the net export surplus that is necessary to sustain a given net external position. By contrast, we emphasize that variations in asset returns and especially the exchange rate may make a given net foreign asset position sustainable, or not. These effects appear to be quantitatively important. Our research should yield new insights into which countries run sustainable trade and current account deficits.

Second, our approach implies a very different channel through which exchange rates affect the dynamic process of external adjustment. In traditional frameworks, fiscal and monetary policies are seen as affecting relative prices on the good markets (competitive devaluations are an example) or as affecting saving and investment decisions and thereby possibly the current account. In our model,

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<sup>30</sup>Modern asset pricing theory faces a similar challenge since high price dividend ratio predict low future returns, not high future dividend growth. Campbell and Cochrane propose an explanation based on habit formation and time-varying risk premium.

<sup>31</sup>See Kouri (1982) and Henderson and Rogoff (1982).

fiscal and monetary policies should also be thought of as mechanisms affecting the relative price of assets and liabilities, in particular through interest rate and exchange rate changes. This means that monetary and fiscal policies may affect the economy differently than in the standard New Open Economy Macro models à la Obstfeld and Rogoff. While early contributions to the intertemporal approach did emphasize intertemporal effects —on real interest rates— of terms of trade or exchange rate movements (see Razin and Svensson (1983)), we emphasize a different mechanism through asset revaluations.

Third, we believe that our research should also prove useful for analyzing the process of external adjustment of emerging market economies. In this context, the single biggest difference between emerging market economies and developed countries concerns the currency of denomination of assets and liabilities. Most emerging market economies are indebted in dollars. A depreciation of their currency, in that context, yields a capital loss. Indeed, suppose that all assets and liabilities are in dollars (the foreign currency), then the return on the net foreign asset portfolio can be expressed as:

$$R_{t+1} \equiv w_t^A \tilde{R}_{t+1}^A - w_t^L \tilde{R}_{t+1}^L + \Delta e_{t+1} - \pi_{t+1}$$

If a country is a net borrower, a depreciation increases the rate of return that must be paid on liabilities and makes the external position less sustainable. This liability mismatch is at the center of a number of models of recent crises (e.g. Thailand, Korea, Argentina...). We propose that our approach may yield important insights into the dynamics of adjustment of the balance of payments in these countries as well as the choice of the optimal exchange rate regime.

## Appendix A: Loglinearization

The law of asset accumulation is given by:

$$\frac{A_{t+1}/A_t - L_{t+1}/A_t}{1 - L_t/A_t} = R_{t+1} \left( 1 + \frac{X_t/A_t - M_t/A_t}{1 - L_t/A_t} \right)$$

For all variable  $Y_t$ , we define:

$$\hat{y}_t = \ln\left(\frac{Y_t}{\bar{Y}}\right)$$

Capital letters without time subscripts are steady state values.

$$\begin{aligned} \frac{A_{t+1}/A_t - L_{t+1}/A_t}{1 - L_t/A_t} &= A_{t+1}/A_t \left[ \frac{\frac{L_{t+1}}{A_{t+1}} - 1}{L_t/A_t - 1} \right] = G^A \left( 1 + \widehat{g_{t+1}^A} \right) \frac{\frac{L}{A}(1 + \widehat{l_{t+1}} - \widehat{a_{t+1}}) - 1}{\frac{L}{A}(1 + \widehat{l}_t - \widehat{a}_t) - 1} \\ &= G^A \left( 1 + \widehat{g_{t+1}^A} \right) \left( 1 + \frac{\frac{L}{A}}{\frac{L}{A} - 1} (\widehat{l_{t+1}} - \widehat{a_{t+1}}) \right) \left( 1 - \frac{\frac{L}{A}}{\frac{L}{A} - 1} (\widehat{l}_t - \widehat{a}_t) \right) \\ &= G^A \left( 1 + \widehat{g_{t+1}^A} + \frac{L}{L - A} [\widehat{l_{t+1}} - \widehat{a_{t+1}}] - \frac{L}{L - A} [\widehat{l}_t - \widehat{a}_t] \right) \end{aligned}$$

$$\begin{aligned} \frac{X_t/A_t - M_t/A_t}{1 - L_t/A_t} &= \frac{\frac{X}{A}(1 + \widehat{x}_t - \widehat{a}_t) - \frac{M}{A}(1 + \widehat{m}_t - \widehat{a}_t)}{1 - \frac{L}{A}(1 + \widehat{l}_t - \widehat{a}_t)} \\ &= \frac{X - M}{A - L} \left[ 1 + \frac{X}{X - M} (\widehat{x}_t - \widehat{a}_t) - \frac{M}{X - M} (\widehat{m}_t - \widehat{a}_t) - \frac{L}{L - A} (\widehat{l}_t - \widehat{a}_t) \right] \end{aligned}$$

Therefore

$$\begin{aligned} &G^A \left( 1 + \widehat{g_{t+1}^A} + \frac{L}{L - A} [\widehat{l_{t+1}} - \widehat{a_{t+1}}] - \frac{L}{L - A} [\widehat{l}_t - \widehat{a}_t] \right) \\ &= R(1 + \widehat{r_{t+1}}) \left[ 1 + \left( \frac{X - M}{A - L} \right) \left[ 1 + \frac{X}{X - M} (\widehat{x}_t - \widehat{a}_t) - \frac{M}{X - M} (\widehat{m}_t - \widehat{a}_t) - \frac{L}{L - A} (\widehat{l}_t - \widehat{a}_t) \right] \right] \end{aligned}$$

Hence

$$\begin{aligned} &\widehat{g_{t+1}^A} + \frac{L}{L - A} [\widehat{l_{t+1}} - \widehat{a_{t+1}}] - \frac{L}{L - A} [\widehat{l}_t - \widehat{a}_t] \\ &= \widehat{r_{t+1}} + \left[ \frac{\left( \frac{X - M}{A - L} \right)}{1 + \left( \frac{X - M}{A - L} \right)} \right] \frac{X}{X - M} (\widehat{x}_t - \widehat{a}_t) - \frac{M}{X - M} \left[ \frac{\left( \frac{X - M}{A - L} \right)}{1 + \left( \frac{X - M}{A - L} \right)} \right] (\widehat{m}_t - \widehat{a}_t) \\ &\quad + \frac{L}{A - L} \left[ \frac{\left( \frac{X - M}{A - L} \right)}{1 + \left( \frac{X - M}{A - L} \right)} \right] (\widehat{l}_t - \widehat{a}_t) \end{aligned}$$

since in the steady state

$$\frac{G^A}{R} = \frac{X - M}{A - L} + 1$$

Define

$$\rho = 1 + \frac{X - M}{A - L}$$

so that

$$\frac{\left(\frac{X-M}{A-L}\right)}{1 + \left(\frac{X-M}{A-L}\right)} = 1 - \rho^{-1}$$

The steady state equality implies

$$0 < \rho < 1$$

Define

$$\begin{aligned} nx_t &= \frac{X}{X - M} \widehat{x}_t - \frac{M}{X - M} \widehat{m}_t \\ na_t &= \frac{A}{A - L} \widehat{a}_t - \frac{L}{A - L} \widehat{l}_t \end{aligned}$$

We can rewrite the loglinearization as

$$\begin{aligned} &\widehat{a}_{t+1} - \widehat{a}_t - \frac{L}{L - A} \widehat{a}_{t+1} + \frac{L}{L - A} \widehat{a}_t + \frac{L}{L - A} \widehat{l}_{t+1} - \frac{L}{L - A} \widehat{l}_t \\ &= \widehat{r}_{t+1} + (1 - \rho^{-1}) nx_t - (1 - \rho^{-1}) + \frac{L}{A - L} (1 - \rho^{-1}) (\widehat{l}_t - \widehat{a}_t) \end{aligned}$$

Therefore

$$\Delta na_{t+1} = \widehat{r}_{t+1} + (1 - \rho^{-1}) (nx_t - na_t)$$

And by iterating forward and using the transversality condition  $\lim_{j \rightarrow \infty} \rho^j (nx_{t+j} - na_{t+j}) = 0$

we have :

$$nx_t - na_t = \sum_{j=1}^{+\infty} \rho^j [r_{t+j} - \Delta nx_{t+j}]$$

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