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The Elephant Hiding in the Room: Currency Intervention and Trade Imbalances

Joseph E. Gagnon

Abstract

Official purchases of foreign assets—a broad definition of currency intervention—are strongly correlated with current account (trade) imbalances. Causality runs in both directions, but statistical analysis using instrumental variables reveals that the effect of official asset purchases on current accounts is very large. A country's current account balance increases between 60 and 100 cents for each dollar spent on intervention. This is a much larger effect than is widely assumed. These results raise serious questions about the efficiency of international financial markets.

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Joseph E. Gagnon is a senior fellow at the Peterson Institute for International Economics in Washington, DC.

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Peterson Institute for International Economics

1750 Massachusetts Avenue, NW Washington, DC 20036-1903
Tel: (202) 328-9000 Fax: (202) 659-3225 www.piie.com

I. INTRODUCTION

Current account (or trade) imbalances grew to record levels just before the global financial crisis of 2008. At the same time purchases of foreign assets by governments also reached record levels. Over the past five years, both current account imbalances and official asset purchases have retreated somewhat, but remain at historically high levels. An obvious question is whether there is a causal relation between these phenomena. Figure 1 shows a striking correlation between aggregate current account balances and aggregate net official financial flows of countries with large stocks of official foreign assets as of 2010.

Few people would say that the correlation in figure 1 is a coincidence, but some have argued that the causality runs from current accounts to official asset accumulation. In their view, governments in these countries chose to accumulate foreign assets because they had current account surpluses. That may be, but it is also possible that governments chose to make large purchases of foreign assets in order to prevent currency appreciation that would have kept current accounts close to balance. The key question is whether the large current account surpluses would have occurred, or would have been as persistent, if governments had not bought any foreign assets.

This paper finds that the large current account imbalances shown in figure 1 probably would not have occurred, and certainly would not have persisted, without massive official net purchases of foreign assets. This result suggests that international financial markets are not very efficient at equalizing rates of return across countries. This result also suggests that the problem of global current account imbalances may be more readily corrected through policy actions than is generally believed. C. Fred Bergsten and I explore the implications of the latter point in a recent policy brief (Bergsten and Gagnon 2012).

II. A MODEL

Definitions

Current accounts and financial flows are linked by a fundamental accounting identity. In the absence of measurement error, the current account exactly equals the sum of net official and net private financial flows. This is because any net imbalance of current transactions (trade and income) must be financed by an equal and offsetting imbalance of financial transactions. This relationship is known as the balance of payments (BOP) identity. Errors and omissions in measurement prevent the BOP identity from holding exactly in the data. However, as is shown in the next section, errors and omissions are relatively small.

$NOF = NOF^T + v1$	Net official flows, measured with error v1
$NPF = NPF^T + v2$	Net private flows, measured with error v2
$CAB = CAB^T + v3$	Current account balance, measured with error v3
$CAB^T = NOF^T + NPF^T$	True BOP identity
$CAB = NOF + NPF + ERR$	Measured BOP identity

ERR = v3 – v1 – v2	Errors and omissions
X (vector)	Exogenous variables for CAB and NPF
Z (vector)	Exogenous variables for NOF (instruments)

Exogenous variables, X, for CAB and NPF include the cyclically adjusted fiscal balance, the level of economic development, population aging, capital controls, and other factors. NOF may respond in part to the same factors that influence CAB and NPF, but we assume that there are other variables, Z, that influence NOF independently of factors that drive CAB and NPF. Candidates for Z include, for example, the lagged ratios of the stock of official foreign assets (reserves) to imports or to external short-term debt.

Semi-Structural Model

A structural economic model is based on economic theory and may include effects of endogenous variables on each other subject to restrictions implied by the theory. A reduced form model relates each endogenous variable to the exogenous variables and typically does not impose any theoretical restrictions. The model presented here is semi-structural. It expresses the endogenous variables in terms of exogenous variables with one exception, the response of NPF to NOF. There are two advantages to this approach. First, it imposes relatively simple theoretical assumptions on the data. Second, it does not require data on the real exchange rate and the real rate of return, which are important elements of any structural model of these variables. The real exchange rate is not observed except in the form of an index that is not comparable across countries.[1] In addition, it is likely that available measures of the real exchange rate and the real rate of return do not fully capture movements in relative prices and rates of return that are perceived by participants in the markets for goods, services, and finance. Appendix 1 develops a fully structural model that is used to interpret and support the approach taken here.

(1) $$NOF = A \times X + \alpha \times u2 + B \times Z + u1 + v1$$

(2) $$NPF = \lambda \times NOF^{T} + C \times X + u2 + v2$$

Individual capital letters denote vectors of coefficients and variables. Lower case letters and the endogenous variables CAB, NOF, and NPF are scalars. Because governments may use NOF to stabilize their exchange rates, equation 1 allows NOF to react to the same factors that drive NPF, including the unobserved random error in NPF, u2. In addition, NOF responds to the instruments, Z, and there is an unobserved error, u1, and a measurement error, v1.

1. The Penn World Table attempts to measure the real exchange rate in a form that is comparable across countries, at least from the point of view of consumers, but it is not clear how successful the attempt is (Heston, Summers, and Aten 2012). Moreover, other unobserved factors, such as implicit trade barriers and differences in market competition, have important effects on the concept of the real exchange rate that matters for international trade and finance.

Equation 2 is the key equation of the paper. NPF responds to all factors that affect financial flows directly as well as factors that operate indirectly through trade and income flows in the CAB. These are summarized in the vector X and the error u2. The question of interest is how NPF responds to NOF, as captured by the coefficient λ. If $\lambda = 0$, then NOF has a large effect on CAB, as shown in the BOP identity. If $\lambda = -1$, then NPF fully offsets whatever actions governments take and NOF has no effect on CAB.

Appendix 1 demonstrates in a structural model that the extreme values of $\lambda = -1$ and 0 correspond to the cases of fully efficient financial markets and no financial arbitrage, respectively. In other words, when rates of return are fully equalized across countries, $\lambda = -1$, and when financial markets do not respond at all to differentials in rates of return across countries, $\lambda = 0$. *The goal of this paper is to estimate* λ.

First-Stage Regression

Because NOF is endogenous with respect to CAB and NPF, regressing NPF on NOF as in equation 2 yields a biased estimate of λ. Appendix 1 explores the nature of the bias. If the shock to NPF, u2, arises primarily from the financial sector, then λ is biased downward (more negative). If the shock to NPF arises primarily from the trade sector, then λ may be biased either upward or downward, depending on the values of the underlying parameters. The empirical results below demonstrate the importance of downward bias in λ arising from financial shocks.

A two-stage method is required to obtain an unbiased estimate of λ. The first stage is to regress NOF on X and Z as suggested by equation 1. The fitted value, $\widehat{NOF}$, is displayed in equation 3.

(3) $$\widehat{NOF} = A \times X + B \times Z$$

Second-Stage Regressions

Equation 2 can be estimated using the fitted value, $\widehat{NOF}$, as shown in equation 4. The error term u2 has been replaced by w2 because $\widehat{NOF}$ differs from NOF^T. The measurement errors are unaffected. The BOP identity can be used to create an alternative estimating equation, shown as equation 5. Because of measurement error and because $\widehat{NOF} \neq NOF$, a regression based on equation 4 need not yield the same estimate of λ as a regression based on equation 5. One approach is to conduct seeming unrelated regressions (SUR) on equations 4 and 5, imposing the cross-equation restrictions on the coefficients and allowing unrestricted error covariance.

(4) $$NPF = \lambda \times \widehat{NOF} + C \times X + w2 + v2$$

(5) $$CAB = (1+\lambda) \times \widehat{NOF} + C \times X + w2 + v3$$

It is important to note that the estimate of λ in equation 5 is equal to the coefficient on NÔF minus 1. The regression results reported in this paper display estimates of λ. But the question of broader interest is, “what is the effect of currency intervention on current account (trade) imbalances?” *The effect of NOF on the CAB is 1+λ.*

Exogenous Variables: X

Elements of X commonly used in previous studies include lagged net foreign assets, the fiscal balance, per capita GDP relative to that in the United States, the trend growth rate of GDP, the population growth rate, levels or changes of age dependency ratios, and net oil or net energy exports (Chinn and Prasad 2003, Gruber and Kamin 2007, Chinn and Ito 2008, Cheung, Furceri, and Rusticelli 2010, Gagnon 2012, IMF 2012, and Bayoumi and Saborowski 2012). In this paper, the included X variables are cyclically adjusted general government net lending (FISCAL), lagged net private foreign assets (NPFA), lagged per capita GDP relative to that of the United States in PPP terms (YPPP), a forecast of GDP growth over the next five years (YFORE), lagged public spending on health (HEALTH), net energy exports (ENERGY), the expected change over the next 20 years in the ratio of elderly to working-age population (AGING), and a measure of capital controls (CAPCON).[2] A full set of time dummies is added to allow for common movements in current accounts reflecting the global current account discrepancy. Time dummies also allow for a generalized spillover of the effects of NOF on the CABs of all countries equally.[3] All variables are defined in appendix 2.

Exogenous Variables (Instruments): Z

There are two sets of instruments used in this paper, labeled “between” and “within.” The between instruments allow for NOF policies to differ across countries in an unrestricted way. The between instruments consist of dummy variables for each country (also known as country fixed effects in a panel regression framework) plus the country dummies multiplied by lagged gross official assets divided by imports.[4] The between instruments also include the ratio of net energy exports to GDP only for countries and time periods in which there exists an explicit public-sector natural resource sovereign wealth fund (OIL_SWF). The latter variable is not interacted with the country dummies. The between instruments allow each country to have a different desired stock of reserves. They utilize the cross-country information in the data while omitting high-frequency fluctuations in NOF over time that might be driven by shocks to NPF.

2. The level of the old-age dependency ratio, both the level and change of the youth dependency ratio, and the population growth rate are not statistically significant.

3. Alternative allocations of the spillover effects are considered in section IV.

4. Similar results are obtained using lagged net official assets (NOFA) divided by GDP.

The within instruments also allow for NOF policies to differ across countries, but in a much more restricted way that does not require country dummies. The within instruments introduce country variation in policies via interacted variables. The interacted variables allow effects to vary according to a country's stage of development or its history of financial crises. The within instruments are:

- the lagged ratio of gross official foreign assets to imports, to capture deviations of reserves from some desired level based on months of imports;
- the lagged five-year moving average of repayments of IMF credit relative to GDP, to capture a desire to build up net official assets in the aftermath of a financial or currency crisis;
- the ratio of net energy exports to GDP only for countries and time periods in which there exists an explicit public-sector natural resource sovereign wealth fund (OIL_SWF);
- lagged external short-term debt relative to GDP, to capture the Greenspan-Guidotti rule;
- lagged external public and publicly guaranteed debt relative to GDP, which may restrict the usability of gross foreign official assets in a crisis;
- lagged net official assets relative to GDP, to capture reinvestment of earnings on official assets (this proved not to be highly collinear with the first instrument and the debt stocks);
- the first instrument multiplied by relative PPP GDP per capita, to capture different desired reserves levels for rich and poor countries; and
- the first instrument multiplied by the lagged moving average of repayments of IMF credit, to capture any nonlinearity in the relationship between recent crises and desired official assets.

III. EMPIRICAL FINDINGS

Data

The baseline dataset consists of observations on 40 economies over 25 years from 1986 through 2010. These are the same countries and years examined in IMF (2012) except that the euro area is treated as a single economy.[5] The alternate dataset consists of observations on all available countries (115) over the same years. The baseline dataset includes relatively larger and wealthier countries, whereas the alternate dataset is dominated by smaller and poorer countries. In the alternate dataset, euro area members are treated as separate economies. There are many missing observations for the early years of the sample, especially in the alternate dataset. Some variables have fewer missing observations than others; thus, the number of observations used in the regressions varies across specifications.

5. Differences in NOF are meaningless within a currency union, and members of the euro area had tightly linked exchange rate and monetary policies even before the start of the union in 1999. Regression fit is uniformly better with the euro area treated as a single economy than as separate economies.

Analysis proceeds both at the annual frequency and at the five-year frequency. Most studies in this area have used non-overlapping five-year averages of the data to reduce the effects of dynamic adjustment and to focus on medium-term determinants of CABs.

Table 1 presents summary statistics of the baseline dataset at the annual frequency. All data are expressed in percentage points of GDP. For the raw (pooled panel) data the CAB is strongly positively correlated with both NOF and NPF, while NOF and NPF have a strong negative correlation. Both the CAB and ERR have mean values close to 0, but NOF is noticeably positive on average and NPF is noticeably negative.[6] The volatilities (standard deviations) of CAB, NOF, and NPF are quite similar. ERR is much less volatile, which suggests that measurement error is not a first-order concern with these data.

The next section of table 1 focuses on information across countries (between effects). There is a very strong correlation across countries between CAB and NOF and essentially no correlation between NOF and NPF. This is suggestive of a powerful effect of NOF on CAB with little or no offset from NPF and thus a small value of λ. To argue otherwise requires the following combination of assumptions: (1) shocks to CAB are larger than other shocks (this is supported by the standard deviations); (2) governments aggressively attempt to stabilize their real exchange rates through accommodative purchases of foreign assets (NOF); and (3) NPF would have supported the changes in CAB even in the absence of NOF. But the latter assumption implies that the CAB shocks should not have had much effect on the real exchange rate, in which case governments would not have felt compelled to intervene. A more plausible interpretation is that the first two assumptions are correct but the third is not. This means that if governments had not used NOF aggressively to stabilize their exchange rates, their CABs would not have deviated so much across countries. Note also that these data are averages over 25 years; this suggests that governments are not stabilizing their exchange rates around equilibrium levels, but rather are perpetuating CAB imbalances through NOF imbalances.

The final section shows correlations within countries over time. On this measure, NPF is more strongly correlated with CAB than NOF is. NPF also has the largest volatility and CAB the lowest, with NOF in between. Note, however, the large negative correlation between NOF and NPF. A plausible interpretation of this section is that (1) volatility within countries over time is driven by NPF; (2) NOF responds to partially offset the effect of these volatile private flows on the real exchange rate; and (3) the partial NOF response damps movements in the CAB that would otherwise occur, which is consistent with a low correlation between NOF and CAB.

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6. Nonzero mean values for NOF and NPF reflect the fact that official flows are recorded as such only for the country whose government is making the transaction. For the country on the other side of the transaction, official flows are recorded as private flows with opposite sign. Section IV considers the implications of reclassifying flows into recipient countries as negative official flows rather than negative private flows.

Figure 2a displays some of the information in the middle part of table 1, showing the strong positive correlation of CAB and NOF. Singapore (SG) is an outlier; it is consistent with a positive correlation, but the correlation among the remaining countries is strongly positive without Singapore (figure 2b). Figures 3a and 3b display the information in the bottom part of table 1. The data are displayed as five-year moving averages to focus on the medium-term relationships. There is often a clear positive correlation between CAB and NOF, but there are several cases of low or possibly negative correlations. To understand the connections better we need to control for other factors influencing the CABs.

Baseline Regressions

Table 2 presents the baseline regression results using five-year averaged data. The first three columns present regressions of equations 4 and 5 using NOF instead of NÔF (no first-stage regression). The first column, labeled NPF, is a regression of equation 4 allowing for an autocorrelated error. The second column, labeled CAB, is a similar regression of equation 5. The third column, labeled SUR, is a seemingly unrelated regression (SUR) of equations 4 and 5 together, imposing the cross-equation restrictions on the coefficients and allowing for a general covariance matrix. The SUR regression does not correct for autocorrelated errors, but the other columns show that autocorrelation in the individual-equation regressions appears to be rather low. The top row shows estimates of the coefficient λ—*note that for the CAB regressions, these are the regression coefficients minus 1*.

The results in tables 2, 3, and 4 present interesting examples of Hausman's (2001) "iron law of econometrics" that coefficient estimates tend to be biased toward zero. Because the estimate of λ from the CAB regression requires subtracting 1 from the regression coefficient, it is biased toward –1. Indeed, in every case, the estimate from the NPF regression is larger (less negative) than the estimate from the CAB regression. Thus, to some extent, the truth should lie between the estimates from the NPF and CAB regressions.

The estimates of λ in the first three columns lie between the extremes of full offset, –1, and no offset, 0, of NOF by NPF. However, the bias from simultaneity may be in either direction. (See appendix 1 for a discussion of the biases based on a structural model.) We proceed next to estimates that employ instrumental variables to remove this bias.

The middle three columns of table 2 display regressions using fitted values of NOF based on the "between" instruments.[7] The between instruments allow for differences in NOF policies across countries

7. The second-stage regressions were run separately from the first-stage regressions in order to allow for autocorrelated and heteroskedastic errors. Using the instrumental variables estimator in STATA allows for coefficient standard errors that appropriately reflect information from the first-stage regression under the assumption of non-autocorrelated homoskedastic errors. The resulting coefficients are never significantly or even noticeably different from those in table 2 and the standard errors are similar.

with minimal restrictions; this uses up many degrees of freedom in the first-stage regression.[8] A critical element of a good instrument set is that the additional information from the instruments (Z) relative to the other exogenous variables (X) should be substantial. As shown at the bottom of the table, the R^2 of a regression of NOF on X is 0.40, whereas the first-stage regression (NOF on X and Z) has an R^2 of 0.81, implying that the instruments (Z) do have significant additional explanatory power for NOF. However, there is a risk that too many instruments may over-fit NOF, spuriously reintroducing endogenous responses to CAB and NPF.

The top row of the middle three columns shows that λ is estimated to be closer to zero in all of the regressions using the between instruments compared the regressions without instruments. This suggests that the simultaneity bias is downward and that NPF does not respond very much to NOF.

The final three columns of table 2 display regressions using "within" instruments. The first-stage regressions show a reasonable degree of explanatory power in the within instruments while using fewer degrees of freedom than the between instruments. The regressions using the within instruments also show little evidence of an NPF response to movements in NOF (λ is small) and thus imply a large effect of NOF on CAB.[9] Indeed, the positive values of λ in these regressions suggest that private capital follows official capital rather than offsetting it, but the coefficients are small and, at most, marginally significant. The regressions in table 2 suggest that the close correlation of NOF and CAB in figure 1 may be structural.

The coefficients on the X variables all have correct signs and plausible magnitudes except for the fiscal coefficient, which is lower than typically estimated in previous studies. This probably reflects some fiscal effects implicit in the other variables, including health expenditures, aging, and energy exports. It also reflects a significant degree of collinearity between FISCAL and NOF. In regressions with a more negative estimate of λ, the coefficient on FISCAL tends to be larger (as is apparent in the next table).

It is somewhat surprising that the SUR estimates of λ do not lie between the estimates from the NPF and CAB regressions. This probably results from the lack of correction for autocorrelation in the residuals of the SUR regression. For this reason, it may be best to focus on the average of the NPF and CAB estimates. None of the above results is significantly affected by dropping ENERGY from the X variables and OIL_SWF from the Z variables.

Overall, the baseline results suggest no significant offset of NOF by NPF. This result implies that NOF has a very large effect on CAB.

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8. All countries have three, four, or five observations. For countries with only three observations, the interaction term with lagged official assets is dropped to prevent a spuriously close fit.

9. Hausman tests cannot reject that NPF is exogenous with respect to NOF using either the between or within instruments.

Alternate Regressions

Table 3 displays regression results for the alternate dataset, which has more than twice as many observations. The estimates of λ (top row) are somewhat more negative than those in table 2. With the between instruments it appears that a bit more than one-third of movements in NOF are offset by NPF.[10] This still implies a large and statistically significant effect of NOF on the CAB. There is a risk of over-fitting NOF in the first stage, as seen by the large number of first-stage variables (shown in the bottom row) relative to total observations.[11] The within instruments are much more parsimonious, while retaining substantial marginal explanatory power, and they lead to estimates of λ close to 0.

Estimates of the fiscal coefficient are now somewhat larger than those in table 2. Fiscal estimates in the middle three columns are close to those estimated by Kamin and Gruber (2007), Chinn and Ito (2008), and Cheung, Furceri, and Rusticelli (2010). The growth forecast and health expenditures data are not available for the broader country sample. In place of a growth forecast, the regression uses the lagged five-year moving average of GDP growth, but it never has a significant coefficient. All of the other coefficients have the correct sign and plausible magnitudes. Some of the other coefficients are not comparable to those in table 2 because the data are defined differently. For example, table 3 uses projected aging over 10 years whereas table 2 uses projected aging over 20 years. Also, the capital controls variable is that of Chinn and Ito (2006, updated) which was available for more countries than that of Quinn (1997, updated). The coefficient on YPPP is smaller than in the baseline regressions, possibly reflecting a non-linearity in the effect of this variable that becomes apparent when low-income countries are included in the sample. (The baseline sample includes almost exclusively middle-income and high-income countries.)

Table 4 presents regressions using the baseline dataset at an annual frequency. The SUR results are not included because they do not allow for autocorrelated errors, which are statistically significant with annual data. The negative bias in the regressions without instruments (first two columns) is greater than it was using five-year averaged data. This suggests that high-frequency financial market shocks are important and that governments use NOF to offset the effects of such shocks on the real exchange rate and the CAB. Using the two-stage procedure with appropriate instruments is especially important with annual data.

The estimates of λ with between instruments are somewhat more negative than those in table 2, but they remain far from –1. The estimates of λ using within instruments display a wide discrepancy between the NPF regression and the CAB regression, possibly reflecting the low marginal explanatory power of the

10. Countries with only one observation are dropped from the between instruments regression. For countries with either two or three observations, the interaction term with lagged official assets is dropped from the instrument set.

11. Conducting the first-stage regression with annual data and taking five-year averages of the fitted value of NOF leads to noticeably smaller estimates of λ with between instruments: –0.21 and –0.33, for NPF and CAB regressions, respectively.

Z variables in the first-stage regression. On average, they are similar to the within-instrument estimates of λ in table 2.

Annual regressions on the alternate dataset (not shown) produce estimates of λ very close to those in table 4. The results also are not sensitive to allowing for country-specific autocorrelated errors.

The alternate regressions confirm that the effect of NOF on NPF is closer to 0 than to –1 and the effect of NOF on CAB is closer to 1 than to 0.

Further Tests

Table 5 presents regressions on country averages of the data, otherwise known as "between effect" regressions. It is not possible to use the between instruments because they would use all available degrees of freedom. The instruments here are the within instruments using annual data. The fitted value of NOF in the second stage is the average fitted value for each country from the first stage. The first four columns show that the cross-country information in the baseline sample strongly suggests that there is no offset of NOF in NPF (λ=0) or even a small tendency of NPF to follow NPF. This is consistent with figures 2a and 2b. Columns 5 and 6 display estimates of λ close to 0 in the alternate dataset when instruments are used.

The final two columns of table 5 present results of a cross-country regression in the year 2010 of the stock of net foreign assets (NFA, ratio to GDP) on net official foreign assets (NOFA, ratio to GDP), gross government debt (GDEBT, ratio to GDP), the lagged level of YPPP, a 10-year lag of AGING, and CAPCON. This specification is shown in equation 6, where the auxiliary variables are expressed by the vector X.

(6) $$\text{NFA} = \mu \times \text{NOFA} + D \times X$$

NFA, NOFA, and GDEBT are essentially cumulations of CAB, NOF, and FISCAL, respectively. Thus, equation 6 is a stock analog of equation 5, which is in flows.[12] μ is the analog of 1+λ and it is displayed in the top row of columns 7 and 8 of table 5. These results show that differences in NOFA across countries have a dollar-for-dollar relationship with differences in total NFA, suggesting no private-sector offset of official financial flows.

It is not clear what instruments could be used for NOFA in equation 6. It may be argued that in the long run, stocks of official assets are driven by exogenous factors such as a country's desire for a war chest against crises or saving for future generations. In that case no instruments are needed. If, on the other hand, governments allow official assets in the long run to be the by-product of past attempts to stabilize the real exchange rate, then the coefficients in the top row of columns 7 and 8 of table 5 are potentially

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12. Because NFA is constructed by summing over NOFA and NPFA, there is no independent information available that would make it useful to estimate an analog of equation 4.

biased. But the estimated coefficients are extremely large. If the true value of μ were 0, an estimated value of 1 would imply that countries have chosen to target exactly the value of the real exchange rate that private markets would have chosen anyway.[13] However, in that case there would have been no pressures on the exchange rate that would have given governments a reason to purchase official assets. This suggests strongly that $\mu > 0$, implying that $\lambda > -1$.

Table 6 presents regressions that include a full set of country dummies. These results essentially are based on deviations from country averages and are also known as "within effects" regressions. The within instruments (Z) have very low marginal explanatory power when the exogenous variables (X) include country dummies, so only the between instruments are used. There is a risk of over-fitting, especially in the regressions on five-year averages. To minimize this risk, the fitted values of NOF in the regressions with five-year data are averages of the annual fitted values of NOF.[14]

The estimates of λ are generally more negative than in the previous tables. There is much more evidence of NPF offsetting NOF over time than across countries. In part, this may reflect longer lags in trade (CAB) than in finance (NPF) so that the effects of NOF on CAB through the real exchange rate are not fully captured by regressions without adjustment lags. Another concern is the very low marginal explanatory power of the first-stage regressions, evidenced by the small differences in the R^2s in the bottom row despite the addition of a large number of Z variables. Poor first stage fit tends to be associated with erratic estimates of λ. Nevertheless, in most specifications, the hypothesis of full NPF offset of NOF ($\lambda = -1$) can be rejected.

Overall, the information in the data across countries, including that contained in asset stocks as well as flows, strongly suggests a large effect of NOF on CAB with very little offset from NPF. The information within countries over time is less informative and potentially subject to greater biases; it suggests significant effects of NOF on both CAB and NPF.

IV. DISCUSSION OF RESULTS

Comparison to Results in IMF (2012)

In their pilot External Balance Assessment (EBA), staff at the International Monetary Fund (IMF 2012) find that λ is not significantly different from –1 in a regression of the form of equation 5. This section explores the differences in implementation that lead to the difference in this estimate.

13. If true $\mu=0$, then NOF does not influence the real exchange rate. Attempting to target anything other than the equilibrium exchange rate will give rise to offsetting NPF, which will cause estimated $\mu<1$. Estimated $\mu=1$ only if governments choose to purchase exactly as many foreign assets as the private sector would have done anyway.

14. Compared to running the first-stage regression in five-year averages, this approach has little effect on the estimates of λ for the 115 country sample but yields estimates of λ that are considerably closer to 0 in the baseline sample.

The starting point is the regression in column 4 of table 4, which has the closest specification among the regressions of this paper to that used in the EBA. This regression is repeated in column 2 of table 7. As discussed above, omitted trade adjustment lags may bias down the estimate of λ in annual data, nevertheless the estimate of λ in column 2 is significantly greater than –1. Notice also that the estimate of λ in the companion NPF regression, shown in column 1, is considerably further from –1 than that in column 2. The EBA does not include regressions based on NPF. Recall that Hausman's (2001) Iron Law suggests that the coefficient in column 2 is biased downward, whereas the coefficient in column 1 is biased upward.

Columns 3 and 4 of table 7 display results using the instrument set employed in the EBA: a full set of country dummies, country dummies multiplied by lagged NOF, and country dummies multiplied by the US VXO index of stock market volatility.[15] Because VXO is correlated with shocks to NPF, it is not an appropriate instrument. Lagged NOF also is not appropriate if there is autocorrelation in NOF. Both of these instruments are likely to bias the estimate of λ downward by introducing high-frequency NPF shocks into the second-stage regression. The estimate of λ is noticeably lower in column 4 than in column 2; however, the estimate in column 3 is not lower than that in column 1. The wide discrepancy between the estimates of λ in the NPF and CAB regressions is a warning sign that the fitted values of NOF from the first stage may be poorly estimated.

Another important difference in the regressions of the EBA is the use of net foreign assets (NFA) in place of net private foreign assets (NPFA) among the exogenous variables (X).[16] The difference between these is net official foreign assets (NOFA), which is the cumulation of past NOF. As shown in columns 5 and 6, adding NOFA (through NFA) lowers the estimate of λ. In column 6 the estimate becomes insignificantly different from –1, consistent with the EBA result. Note again the wide discrepancy between the estimates in the NPF and CAB regressions. The estimate of λ in column 5 is significantly different from –1 and much closer to 0.

When NOFA is in the regression, it is not appropriate to draw the conclusion that the effect of official asset purchases is captured entirely by the coefficient on NOF. The effect of NOFA on CAB and NPF reflects the influence of lagged NOF, either through lagged effects on the exchange rate or because NOFA is effectively another instrument for NOF. Because the stock of NOFA is large relative to the flow of NOF, a coefficient of 0.04 implies quite a large effect on CAB. This positive effect should be viewed in tandem with the negative estimate of λ.

15. The first-stage regressions in the EBA do not include the exogenous variables (X). The EBA uses the change in foreign exchange reserves in place of NOF, but this has little effect on the results.

16. Indeed, all previous studies, including Gagnon (2012), use lagged NFA instead of lagged NPFA.

NPFA should be included in the regression because, in a growth equilibrium, countries with high private saving will run CAB surpluses so that their NPFA will grow in line with their economies. The argument for including NOFA relies on Ricardian equivalence—that the private sector sees through the veil of the public sector and chooses NPFA to keep NFA (which equals NOFA+NPFA) at its desired level. It is widely agreed that households are far from fully Ricardian. Moreover, according to the foregoing argument, the effect of NFA should operate entirely through the net income component of the CAB. If anything, the coefficient on NFA in a regression of the non-income component of the CAB should be negative.[17] This is indeed the case for NPFA. However, the coefficient on NOFA in such a regression is positive. This result is at variance with the argument for including NOFA in the main regressions, and it suggests that there are long-lasting effects of NOF on trade flows.

There are many other differences between the regressions of this paper and those of the EBA.[18] But the differences that appear to be important are (1) using NPF as well as CAB as the dependent variable; (2) using five-year average data; (3) avoiding instruments that introduce high-frequency correlations with financial shocks; and (4) not including lagged NOFA among the auxiliary variables.

Capital Controls and NOF

Two recent studies find effects of NOF on CAB that operate entirely through the presence of capital controls (IMF 2012 and Bayoumi and Saborowski 2012).[19] They include in their regressions a measure of NOF multiplied by CAPCON. The coefficient on this term is expected to be positive, because tighter restrictions on capital mobility should be associated with less of a negative response of NPF to NOF. In other words, NPF cannot move to offset NOF if capital controls prevent it.

Adding NOF×CAPCON in the instrumented regressions of tables 2 through 4 almost always results in a coefficient with the wrong sign that is never statistically significant. However, the coefficient on NOF×CAPCON is positive and statistically significant in a regression of equation 5 without instruments, using the alternate dataset at an annual frequency. This is similar to the results of Bayoumi and Saborowski (2012).[20] As discussed above, there are strong reasons to believe that coefficients are biased in regressions of equations 4 and 5 without using first-stage instruments, especially in annual data.

17. The prediction of a negative coefficient in a regression that excludes income flows from the CAB reflects an assumption that the return to capital exceeds the growth rate. Otherwise, the world has too much capital and welfare can be improved by saving less.

18. These include additional X variables in the EBA, time dummies in this paper, different treatment of the euro area in the baseline dataset of this paper, and additional countries in the alternate dataset of this paper.

19. The first paper to suggest such an effect is that of Reinhardt, Ricci, and Tressel (2010), who focus on capital inflows to developing economies.

20. It is also possible to obtain an estimate of λ close to –1 and a positive coefficient on NOF×CAPCON with five-year average data in the alternate dataset using equation 5, the Schindler (2009) measure of capital controls, a measure of NOF

A cruder approach to measuring the effect of capital controls is to divide the sample into two groups of countries: those with more open financial markets and those with more closed financial markets. The coefficient λ should be closer to –1 in the sample with open markets and closer to 0 in the sample with closed markets. The instrumented regressions of table 3 (115 countries, five-year periods) are run on two subsamples: countries with capital mobility (averaged over time) above the median and countries with capital mobility below the median. The estimates of λ always differ in the expected direction, but never to an extent that is statistically significant. With the between instruments (averaging across NPF and CAB regressions) λ is lower by 0.18 in the sample with more open financial markets. With the within instruments, λ is lower by 0.44 with more open markets, but there is a high standard error on the coefficients.

On balance, there is at best only weak evidence that reported measures of capital controls have an important effect on the response of NPF to NOF. This negative result may reflect either that available measures of capital controls do not well capture true differences in capital mobility or that financial markets are not very efficient regardless of the presence or absence of explicit controls.

Spillovers

Apart from measurement error, the sum of all countries' CABs must equal 0. If some countries sustain positive CABs through positive NOFs, other countries must have negative CABs. The use of a complete set of time dummies implicitly allows for the spillover to affect all countries equally in proportion to their GDP. An alternative assumption is to assume that the spillover is focused on the countries that issue the financial assets being purchased.

The IMF reports the currency allocation of about half of the world's stock of foreign exchange reserves in its periodical, *Currency Composition of Official Foreign Exchange Reserves* (COFER). An alternative definition of NOF can be based on the COFER data assuming that all reserves are allocated in the same proportion as those reported in COFER. This assumed allocation is applied only to the reserves component of NOF, but the reserves component is by far the most important. Purchases of dollar reserves are counted as negative official flows for the United States, with net private flows increased by an equal amount. The same is done for the other reserve-issuing economies: the euro area, Japan, Switzerland, and the United Kingdom. In these alternative data, the United States has a large negative NOF, unlike that shown in figure 3b, reflecting that about 60 percent of foreign exchange reserves are held in dollar

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based only on foreign exchange reserves, and total NFA in place of NPFA. The NOF×CAPCON coefficient is significant only when instruments are not used.

assets. The regressions in table 2 are re-run using the alternative NOF data. In most cases, the R^2s increase slightly, but the coefficients are not affected to any noticeable extent.[21]

Another alternative approach to spillovers is to assume that they are greatest where CAPCON is lowest. To the regressions of table 2 is added an interaction term consisting of (1-CAPCON) times the sum of NOF over all countries. The coefficient is expected to be negative, as global NOF spills over into the countries with the most open financial markets. However, the coefficient always has the wrong sign and is never significant.

Overall, the data are not informative on the question of how the spillovers of NOF are allocated across countries.

NOF and FISCAL

There is a moderate degree of collinearity between NOF and FISCAL, reflecting the fact that countries with positive NOF often have budget surpluses. Nevertheless, the coefficients on these variables represent two different effects: (1) the coefficient on NOF captures the effect of a balanced-budget swap of foreign-currency assets for domestic-currency debt; and (2) the coefficient on FISCAL captures the effect of a budget surplus used to buy domestic-currency assets (or pay down domestic-currency debt). Thus, the sum of these coefficients captures the effect of a budget surplus used to buy foreign-currency assets.

Seen in this light, one would expect that the effect of NOF on CAB ($1+\lambda$) plus the coefficient on FISCAL (say, θ) should be no greater than 1, that is, $1+\lambda+\theta < 1$ or $\lambda+\theta < 0$. Except for the country-average regressions in the baseline dataset (table 5), this restriction almost never is violated to any appreciable extent.

One of the surprising results of this research is that budget-neutral shifts in the currency denomination of government assets have a larger effect, dollar for dollar, on the CAB than changes in the budget balance. (In other words, $1+\lambda > \theta$.)

V. CONCLUSION

This paper presents robust evidence that currency intervention, or more broadly, net official purchases of foreign assets, have a powerful and sustained impact on current account (trade) imbalances. In particular, attempts by governments to prevent currency appreciation by buying foreign assets have succeeded in maintaining large current account surpluses. This conclusion holds even after controlling for the endogeneity of official purchases with respect to exchange rates and current accounts.

21. Bayoumi and Saborowski (2012) find that the United States is the principal recipient of spillovers from reserve accumulation, with some weaker evidence of spillovers into emerging-market countries with more open financial markets.

Two recent papers have argued that currency intervention affects current account balances only in countries that restrict private capital mobility. Because the effect of intervention depends critically on the degree to which financial markets are efficient, the theoretical case for a connection to capital controls is compelling. Nevertheless, this paper is not able to find a robust effect of capital controls, and it shows that the earlier results rely on data and specifications that are likely to yield biased estimates. The available measures of capital controls do not appear to be strongly correlated with market efficiency, possibly because even the most open markets are far from being efficient.

The basic parameter estimated in this paper is the extent to which private markets offset government intervention in currency markets. It is possible to get a wide range of estimates, from nearly complete offset to a small but perverse negative offset.[22] The most plausible estimates suggest that private financial flows offset somewhere between 0 and 40 percent of official flows. Because the current account balance is the sum of net private and net official flows, the implied effect on the current account balance is between 60 and 100 percent of net official flows. This is a much larger effect than is widely assumed.

22. Because "offset" is a negative concept, the corresponding range for estimates of λ is –0.9 to 0.4.

Table 1 Summary statistics of external accounts, 1986–2010 (annual data in percentage points of GDP, 40 countries)

	Correlation matrix			Mean	Standard deviation
	CAB	NOF	NPF		
	Pooled panel data				
CAB				–0.2	5.2
NOF	0.43			1.5	5.2
NPF	0.51	–0.49		–1.8	5.3
ERR	0.18	–0.15	0.01	0.1	1.7
	Country averages (between effects)				
CAB				–0.2	4.0
NOF	0.76			1.5	3.1
NPF	0.58	–0.07		–1.8	2.5
ERR	0.38	0.14	0.20	0.1	0.6
	Deviations over time (within effects)				
CAB				0.0	3.4
NOF	0.16			0.0	4.1
NPF	0.54	–0.67		0.0	4.7
ERR	0.12	–0.25	–0.03	0.0	1.6

Note: The statistics in the first section are based on raw data for 40 countries and 25 years with 983 observations. The statistics in the second section are based on averages for each country with 40 observations. The statistics in the third section are based on deviations from country averages with 983 observations.

Source: Author's calculations based on data described in appendix 2.

Table 2 Effect of net official flows (NOF) on net private flows (NPF) (40 countries, five-year averages, 1986–2010)

	No instruments			"Between" instruments			"Within" instruments		
	NPF (1)	**CAB (2)**	**SUR (3)**	**NPF (4)**	**CAB (5)**	**SUR (6)**	**NPF (7)**	**CAB (8)**	**SUR (9)**
NOF (λ)	–0.39*	–0.46*	–0.28*	–0.21	–0.21	–0.10	0.25	0.18	0.30*
	(0.11)	(0.11)	(0.10)	(0.15)	(0.12)	(0.12)	(0.21)	(0.17)	(0.14)
FISCAL	0.10	0.11	0.10	0.06	0.07	0.07	–0.04	–0.03	–0.01
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.06)	(0.08)	(0.08)	(0.07)
NPFA	0.02	0.02	0.03*	0.02*	0.02*	0.03*	0.03*	0.02*	0.03*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
YPPP	0.06*	0.07*	0.06*	0.05*	0.06*	0.05*	0.03	0.04*	0.04*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)
YFORE	–0.78*	–0.75*	–0.76*	–0.87*	–0.86*	–0.84*	–1.14*	–1.07*	–1.05*
	(0.26)	(0.28)	(0.26)	(0.27)	(0.28)	(0.27)	(0.30)	(0.32)	(0.26)
HEALTH	–1.07*	–1.02*	–0.98*	–0.96*	–0.87*	–0.82*	–0.69*	–0.64*	–0.57*
	(0.24)	(0.24)	(0.23)	(0.25)	(0.22)	(0.21)	(0.25)	(0.23)	(0.21)
ENERGY	0.09	0.13*	0.06	0.07	0.10*	0.07	0.03	0.07	0.03
	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.04)	(0.06)	(0.05)	(0.04)
AGING	0.17*	0.16*	0.15*	0.16*	0.14*	0.13*	0.12*	0.11*	0.10*
	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.04)
CAPCON	0.03*	0.04*	0.03*	0.03*	0.04*	0.04*	0.03*	0.04*	0.04*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
AR(1)	0.21	0.24	n.a.	0.19	0.20	n.a.	0.22	0.23	n.a.
R^2	0.38	0.55	.39 .60	0.33	0.58	.36 .62	0.32	0.57	.37 .62
Number of observations	173	173	173	172	172	172	172	172	172
First stage		n.a.			R^2=.81, X and Z: 83 variables R^2=.40, X: 12 variables			R^2=.60, X and Z: 20 variables R^2=.40, X: 12 variables	

* denotes coefficients significant at the 5 percent level using heteroskedasticity-robust standard errors.

Note: NPF denotes regression of equation 4; CAB denotes regression of equation 5 (reported NOF coefficient is regression coefficient minus 1); and SUR denotes seemingly unrelated regression of equations 4 and 5 imposing cross-equation restrictions and allowing unrestricted covariance of residuals. All regressions include a full set of time effects. Instrument sets are defined in appendix 2.

Source: Author's calculations based on data described in appendix 2.

Table 3 Effect of net official flows (NOF) on net private flows (NPF) (115 countries, five-year averages, 1986–2010)

	No instruments			"Between" instruments			"Within" instruments		
	NPF (1)	**CAB (2)**	**SUR (3)**	**NPF (4)**	**CAB (5)**	**SUR (6)**	**NPF (7)**	**CAB (8)**	**SUR (9)**
NOF (λ)	–0.49*	–0.58*	–0.47*	–0.35*	–0.41*	–0.37*	0.11	0.01	0.06
	(0.10)	(0.10)	(0.10)	(0.13)	(0.13)	(0.13)	(0.22)	(0.18)	(0.20)
FISCAL	0.26*	0.28*	0.28*	0.18*	0.18*	0.21*	0.07	0.10	0.10
	(0.06)	(0.07)	(0.07)	(0.07)	(0.08)	(0.06)	(0.08)	(0.07)	(0.07)
NPFA	0.04*	0.04	0.05*	0.05*	0.04*	0.05*	0.04*	0.03*	0.04*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
YPPP	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*	0.01	0.01*	0.01*
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
YGROW	–0.05	0.03	0.03	–0.06	–0.01	0.02	–0.06	–0.04	0.00
	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.08)
ENERGY	0.10*	0.13*	0.10	0.08*	0.11*	0.10*	0.07*	0.11*	0.09*
	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)	(0.03)
AGING	0.27*	0.28*	0.33*	0.20*	0.18	0.26*	0.20	0.15	0.24*
	(0.13)	(0.14)	(0.12)	(0.12)	(0.12)	(0.11)	(0.13)	(0.13)	(0.11)
CAPCON	0.02*	0.03*	0.02*	0.02*	0.02*	0.02*	0.02	0.02	0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
AR(1)	0.24	0.27	n.a.	0.19	0.29	n.a.	0.18	0.28	n.a.
R^2	0.31	0.40	.32 .43	0.23	0.39	.25 .43	0.22	0.42	.24 .45
Number of observations	389	392	389	375	378	375	385	388	385
First Stage		n.a.			R^2=.68, X and Z: 169 variables R^2=.21, X: 11 variables			R^2=.44, X and Z: 19 variables R^2=.22, X: 11 variables	

* denotes coefficients significant at the 5 percent level using heteroskedasticity-robust standard errors.

Note: NPF denotes regression of equation 4; CAB denotes regression of equation 5 (reported NOF coefficient is regression coefficient minus 1); and SUR denotes seemingly unrelated regression of equations 4 and 5 imposing cross-equation restrictions and allowing unrestricted covariance of residuals. All regressions include a full set of time effects. Instrument sets are defined in appendix 2.

Source: Author's calculations based on data described in appendix 2.

Table 4 Effect of net official flows (NOF) on net private flows (NPF) (40 countries, annual data, 1986–2011)

	No instruments		"Between" instruments		"Within" instruments	
	NPF (1)	**CAB (2)**	**NPF (3)**	**CAB (4)**	**NPF (5)**	**CAB (6)**
NOF (λ)	–0.62*	–0.82*	–0.23*	–0.43*	0.42*	–0.09
	(0.04)	(0.03)	(0.12)	(0.09)	(0.18)	(0.17)
FISCAL	0.20*	0.21*	0.15*	0.13*	0.02	0.06
	(0.05)	(0.04)	(0.06)	(0.05)	(0.07)	(0.05)
NPFA	0.02*	0.02*	0.02*	0.02*	0.03*	0.03*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
YPPP	0.06*	0.07*	0.04*	0.05*	0.01	0.04
	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)
YFORE	–0.52*	–0.47*	–0.75*	–0.62*	–1.02*	–0.76*
	(0.13)	(0.11)	(0.16)	(0.12)	(0.18)	(0.13)
HEALTH	–1.01*	–1.02*	–0.83*	–0.82*	–0.45*	–0.64*
	(0.18)	(0.18)	(0.19)	(0.16)	(0.20)	(0.16)
ENERGY	0.18*	0.26*	0.12*	0.21*	0.06	0.20*
	(0.04)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)
AGING	0.21*	0.22*	0.17*	0.19*	0.11*	0.17*
	(0.04)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)
CAPCON	0.03*	0.03*	0.03*	0.03*	0.03*	0.03*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
AR(1)	0.57	0.63	0.49	0.60	0.50	0.64
R^2	0.47	0.37	0.16	0.38	0.16	0.37
Number of observations	838	838	838	838	838	838
First stage	n.a.		R^2=.49, X and Z 113 variables R^2=.25, X 33 variables		R^2=.38, X and Z 41 variables R^2=.25, X 33 variables	

* denotes coefficients significant at the 5 percent level using heteroskedasticity-robust standard errors.

Note: NPF denotes regression of equation 4. CAB denotes regression of equation 5 (reported NOF coefficient is regression coefficient minus 1). All regressions include a full set of time effects. Instrument sets are defined in appendix 2.

Source: Author's calculations based on data described in appendix 2.

Table 5 Between effects (country average) regressions (annual data, 1986–2010)

	40 countries				115 countries		40 Co.	115 Co.
	No instruments		Instruments		Instruments		No instruments	
	NPF (1)	CAB (2)	NPF (3)	CAB (4)	NPF (5)	CAB (6)	NFA[1] (7)	NFA[1] (8)
NOF (λ)	0.23	0.21	0.39	0.41	–0.13	–0.08	1.01*	1.17*
	(0.18)	(0.19)	(0.21)	(0.23)	(0.25)	(0.23)	(0.19)	(0.28)
FISCAL	0.25	0.33	0.19	0.25	0.16	0.22	0.02	–0.43
	(0.17)	(0.18)	(0.17)	(0.18)	(0.17)	(0.16)	(0.04)	(0.28)
NPFA	0.05*	0.05*	0.05*	0.04*	0.06*	0.05*		
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)		
YPPP	0.03	0.03	0.02	0.02	0.02*	0.01*	0.20	–0.06
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.34)	(0.10)
YFORE/ YGROW	–0.55	–0.51	–0.57	–0.50	0.39	0.44*		
	(0.59)	(0.59)	(0.57)	(0.61)	(0.24)	(0.22)		
HEALTH	–0.61	–0.39	–0.46	–0.17				
	(0.35)	(0.35)	(0.36)	(0.18)				
ENERGY	0.04	0.08	0.02	0.05	0.07*	0.09*		
	(0.06)	(0.06)	(0.06)	(0.07)	(0.04)	(0.03)		
AGING	0.14	0.14	0.11	0.10	0.10	0.06	1.07	4.12
	(0.09)	(0.09)	(0.09)	(0.10)	(0.33)	(0.31)	(1.71)	(5.85)
CAPCON	0.02	0.04	0.02	0.03	0.03	0.03	0.16	0.29
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.34)	(0.27)
R^2	0.66	0.86	0.68	0.85	0.30	0.59	0.60	0.18
Number of observations	838	838	838	838	1,947	1,963	39	108
First stage	n.a.		R^2=.38, 41 variables R^2=.25, 33 variables		R^2=.26, 39 variables R^2=.17, 31 variables		n.a.	

* denotes coefficients significant at the 5 percent level using heteroskedasticity-robust standard errors.

1. These are cross-section regressions of net foreign assets (NFA) in 2010 on net official assets, gross government debt, lagged relative per capita GDP (YPPP), the change in old-age dependency over the previous 10 years (AGING), and capital controls (CAPCON). The official assets and government debt coefficients are shown in rows 1 and 2, respectively. Government debt is missing for some countries.

Note: NPF denotes regression of equation 4. CAB denotes regression of equation 5 (reported NOF coefficient is regression coefficient minus 1). First-stage regressions use within instruments (see appendix 2) including a full set of time effects in annual data. Second-stage regressions are based on averages of fitted values for each country.

Source: Author's calculations based on data described in appendix 2.

Table 6 Within effects (deviations from country average) regressions (between instruments, 1986–2010)

	40 countries				115 countries			
	Annual data		Five-year averages		Annual data		Five-year averages	
	NPF (1)	CAB (2)	NPF (3)	CAB (4)	NPF (5)	CAB (6)	NPF (7)	CAB (8)
NOF (λ)	–0.40*	–0.78*	0.00	–0.19	–0.53*	–0.79*	–0.70*	–0.90*
	(0.15)	(0.10)	(0.18)	(0.18)	(0.12)	(0.09)	(0.13)	(0.14)
FISCAL	0.08	0.08	–0.06	–0.06	0.12	0.14*	0.23*	0.23*
	(0.06)	(0.04)	(0.07)	(0.07)	(0.07)	(0.05)	(0.06)	(0.07)
NPFA	–0.02	0.01	–0.04*	–0.02	–0.01	0.01	0.00	0.00
	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
YPPP	–0.07	–0.00	–0.06	0.01	0.02	0.02	0.03*	0.03*
	(0.07)	(0.05)	(0.06)	(0.05)	(0.01)	(0.01)	(0.01)	(0.01)
YFORE/YGROW	–0.75*	–0.53*	–1.26*	–1.29*	–0.30*	–0.31*	–0.18*	–0.19
	(0.17)	(0.11)	(0.27)	(0.25)	(0.10)	(0.09)	(0.09)	(0.10)
HEALTH	–0.60	–0.71*	–0.95*	–1.17*				
	(0.34)	(0.24)	(0.34)	(0.32)				
ENERGY	0.28*	0.44*	0.03	0.07	0.28*	0.41*	0.37*	0.41*
	(0.09)	(0.06)	(0.10)	(0.10)	(0.07)	(0.08)	(0.06)	(0.09)
AGING	0.13	0.09	0.21*	0.13*	–0.13	–0.13	–0.16	–0.10
	(0.09)	(0.06)	(0.08)	(0.06)	(0.18)	(0.12)	(0.14)	(0.14)
CAPCON	0.04*	0.04*	0.04	0.03	0.03*	0.02*	0.03*	0.03*
	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
AR(1)	0.38	0.50	–0.11	–0.04	0.35	0.50	–0.13	–0.04
R^2	0.16	0.29	0.29	0.45	0.12	0.21	0.22	0.30
Number of observations	838	838	172	172	1,919	1,935	380	383
First stage	R^2=.49, 113 variables R^2=.42, 72 variables		Five-year average of fitted annuals		R^2=.41, 227 variables R^2=.34, 134 variables		Five-year average of fitted annuals	

* denotes coefficients significant at the 5 percent level using heteroskedasticity-robust standard errors.

Note: NPF denotes regression of equation 4. CAB denotes regression of equation 5 (reported NOF coefficient is regression coefficient minus 1). All regressions include full sets of country and time effects. Between instruments are defined in appendix 2. R^2 is calculated relative to a base with country-specific means.

Source: Author's calculations based on data described in appendix 2.

Table 7 Comparison to results in IMF (2012) (EBA) (40 countries, annual data, 1986–2010)

	"Between" instruments		EBA instruments[1]		EBA Inst. + NFA[2]	
	NPF (1)	CAB (2)	NPF (3)	CAB (4)	NPF (5)	CAB (6)
NOF (λ)	–0.23*	–0.43*	–0.12	–0.70*	–0.33*	–0.90*
	(0.12)	(0.09)	(0.09)	(0.07)	(0.09)	(0.07)
FISCAL	0.15*	0.13*	0.11	0.22*	0.11	0.20*
	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)	(0.04)
NPFA (NFA)	0.02*	0.02*	0.02*	0.03*	0.04*	0.04*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
YPPP	0.04*	0.05*	0.04*	0.06*	0.01	0.03*
	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
YFORE	–0.75*	–0.62*	–0.83*	–0.45*	–0.79*	–0.41*
	(0.16)	(0.12)	(0.16)	(0.11)	(0.15)	(0.11)
HEALTH	–0.83*	–0.82*	–0.81*	–0.89*	–0.59*	–0.62*
	(0.19)	(0.16)	(0.19)	(0.16)	(0.18)	(0.16)
ENERGY	0.12*	0.21*	0.10*	0.24*	0.12*	0.26*
	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)
AGING	0.17*	0.19*	0.16*	0.21*	0.11*	0.16*
	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)
CAPCON	0.03*	0.03*	0.03*	0.04*	0.03*	0.04*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
AR(1)	0.49	0.60	0.48	0.58	0.46	0.60
R^2	0.16	0.38	0.16	0.36	0.20	0.38
Number of observations	838	838	838	838	838	838

* denotes coefficients significant at the 5 percent level using heteroskedasticity-robust standard errors.

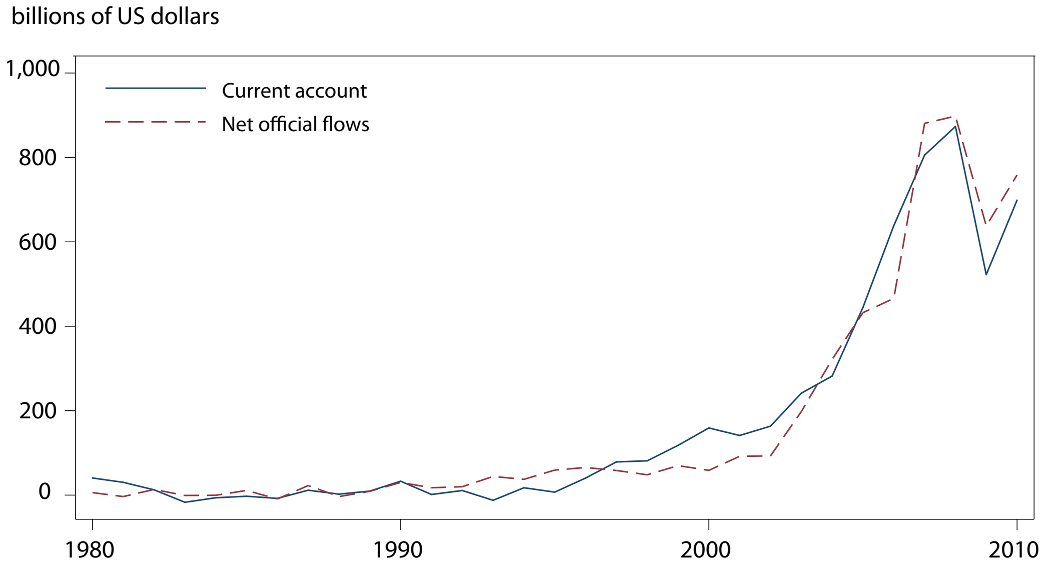
1. EBA instruments are a full set of country dummies, country dummies multiplied by lagged NOF, and country dummies multiplied by the US VXO index of stock market volatility.

2. This regression uses the EBA instruments. In addition, net foreign assets (NFA) are used in place of net private foreign assets (NPFA).

Note: NPF denotes regression of equation 4. CAB denotes regression of equation 5 (reported NOF coefficient is regression coefficient minus 1). All regressions include a full set of time effects. Between instruments are defined in appendix 2.

Source: Author's calculations based on data described in appendix 2.

Figure 1 External balances of large holders of net official foreign assets

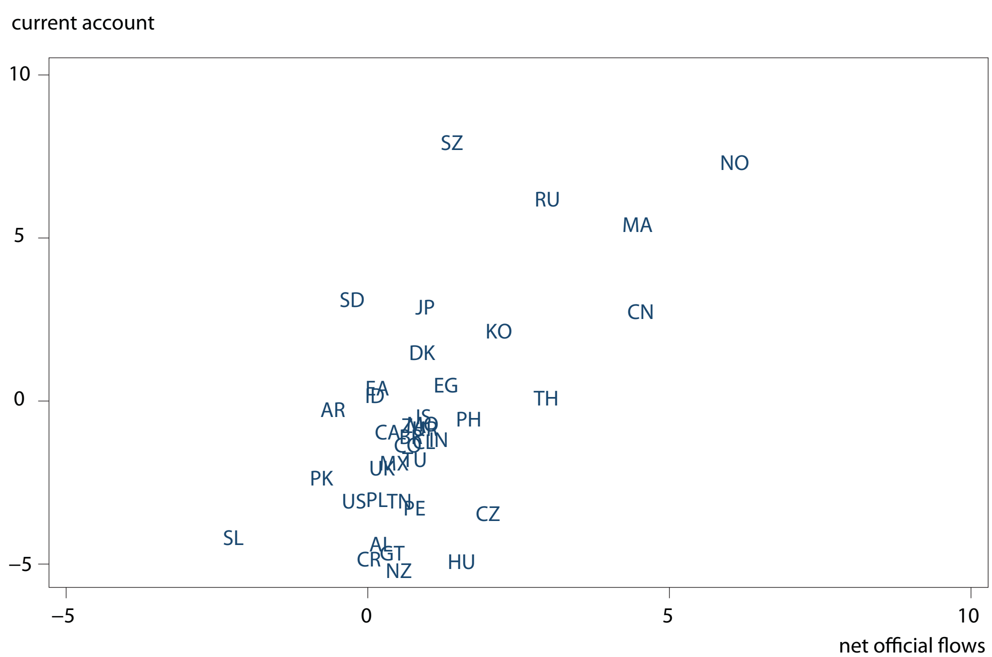


Note: Aggregates for countries in the top decile of net official foreign assets to GDP in 2010.
Sources: See appendix 2.

Figure 2a Current accounts and net official flows, 1986–2010 (averages in percent of GDP)

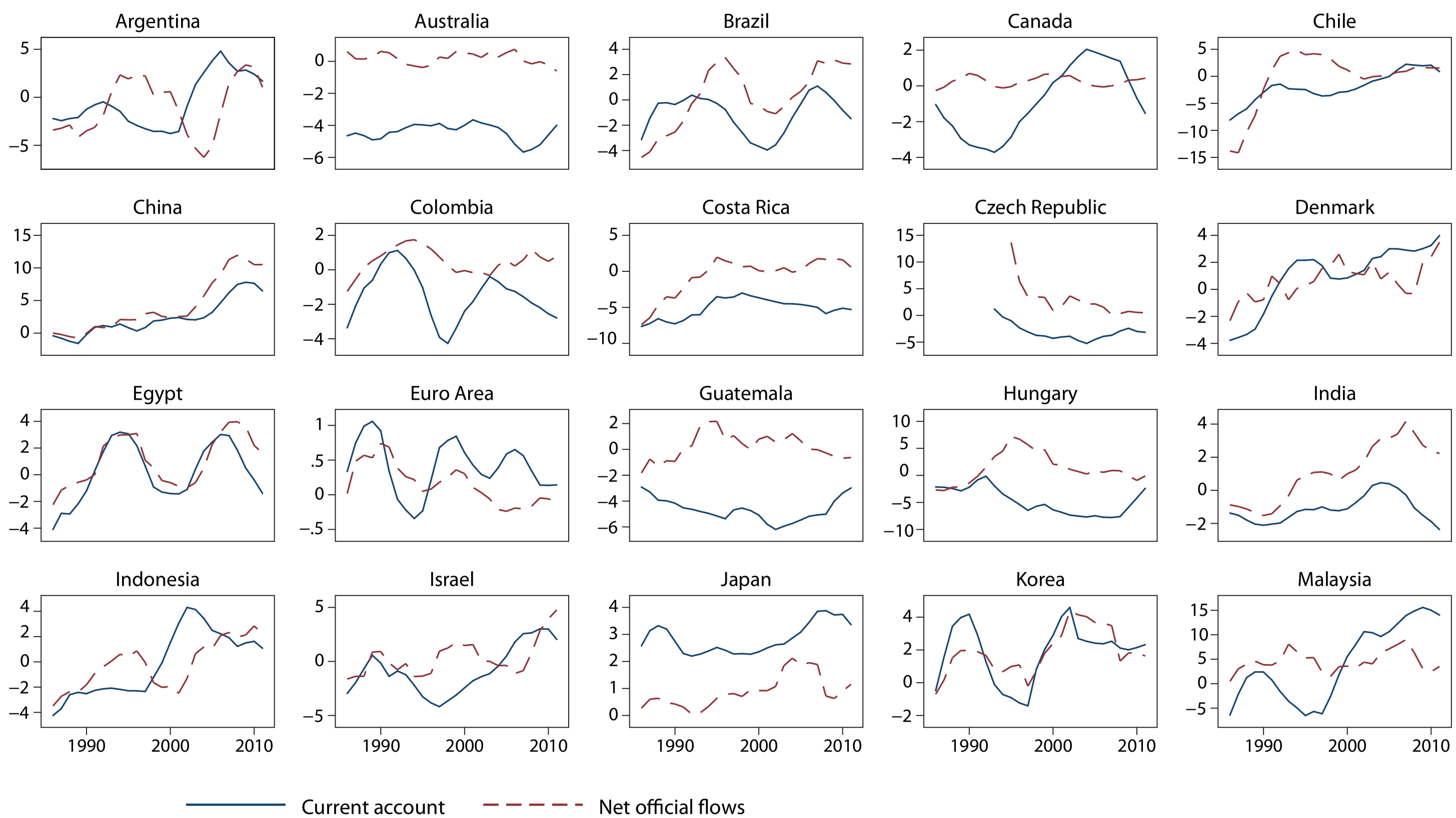
Sources: See appendix 2 for data sources and country codes.

Figure 2b Current accounts and net official flows, 1986–2010 (averages in percent of GDP, excluding SG)



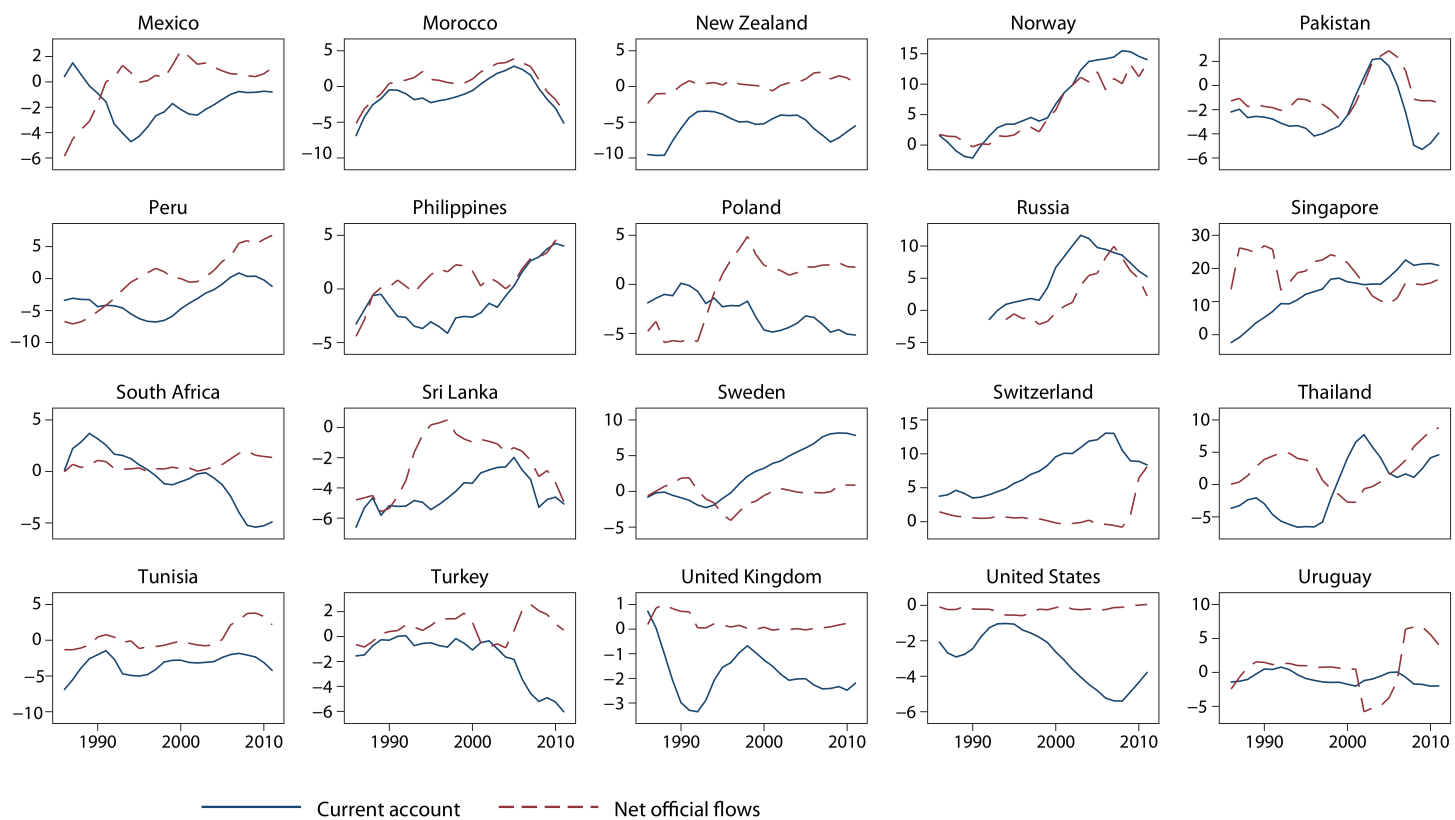
Sources: See appendix 2 for data sources and country codes.

Figure 3a Current accounts and net official flows (percent of GDP, five-year moving averages)



Sources: See appendix 2.

Figure 3b Current accounts and net official flows (percent of GDP, five-year moving averages)



Sources: See appendix 2.

APPENDIX 1: A STRUCTURAL MODEL

For simplicity there are no dynamic terms, shocks are independent across equations and over time, and all variables are normalized at zero in the absence of shocks. All parameters are nonnegative and are denoted by Greek letters.

(A1) $NOF = \alpha \, RER + u1$

(A2) $NPF = \beta \, (RR^* - RR + RER) + u2$

(A3) $CAB = -\gamma \, RER + u3$

(A4) $RR = \delta \, CAB + u4$

(A5) $RR^* = u5$

(A6) $CAB = NOF + NPF$

In equation A1, an increase (appreciation) in the real exchange rate (RER) may induce positive NOF (reserve accumulation) reflecting a desire to push RER down toward zero. In equation A2, NPF responds positively to the excess of foreign real returns (RR*) over domestic real returns (RR). Because RER is expected to return to zero in the future, a positive value of RER increases the return on foreign assets when expressed in domestic currency. Thus, NPF also responds positively to RER. The CAB responds negatively to RER, as shown in equation A3, reflecting standard effects of RER on trade flows. RR responds positively to the CAB, reflecting stabilizing monetary policy in the face of shocks to output (equation A4). RR* is exogenous (equation A5). Finally, equation A6 is the BOP identity.

The efficient markets condition known as open interest rate parity implies that rates of return should be equal across countries, or $RR^* - RR + RER = 0$. Open interest rate parity holds in this model in the limiting case that $\beta = \infty$. In that case, NPF will move as needed to push RER to the level that is required for interest rate parity.

The endogenous variables in the model can be expressed as functions of the exogenous shocks, u1 – u5. This is the "reduced form" of the model. The coefficient of the NOF shock, u1, in the reduced-form equation for NPF is the equivalent of λ in equation 4 of the main text. It predicts the effect on NPF of an exogenous movement in NOF.

(A7) $NPF = -\left[\, \beta \, (1+\gamma\delta) \,/\, (\alpha+\gamma+\beta+\beta\gamma\delta)\right] u1 + \text{terms in } u2 - u5$

As $\beta \rightarrow \infty$, the coefficient on u1 in equation A7 approaches –1. When $\beta = 0$, the coefficient is 0. This supports the assertion that λ in equations 4 and 5 is bounded between 0 and –1, with –1 reflecting fully efficient financial markets and open interest rate parity, and 0 reflecting no tendency for financial markets to arbitrage expected returns across countries.

The structural model also provides insights as to the nature of the bias that results from regressing NPF on NOF directly. For simplicity, and without loss of generality, the bias is calculated on the assumption that there are no auxiliary variables. Under that assumption, the expected regression

Table A1 Theoretical coefficient and expected bias
(equations A1-A6 with γ=.25 and δ=2)

	λ	Bias from each shock in isolation		
		u1	u2, u4, u5	u3
α=.01, β=.01	–0.05	0.00	–26	1
α=.01, β=.1	–0.37	–0.01	–26	9
α=.01, β=1	–0.85	0.00	–25	34
α=.01, β=10	–0.98	0.00	–25	48
α=.1, β=.01	–0.04	–0.02	–3	0.1
α=.1, β=.1	–0.30	–0.08	–3	1.0
α=.1, β=1	–0.81	–0.05	–3	3.5
α=.1, β=10	–0.98	–0.01	–3	4.8
α=1, β=.01	–0.01	–0.04	–1.2	0.00
α=1, β=.1	–0.11	–0.27	–1.1	0.02
α=1, β=1	–0.55	–0.31	–0.7	0.21
α=1, β=10	–0.92	–0.06	–0.3	0.45
α=10, β=.01	–0.00	–0.06	–1.0	–0.02
α=10, β=.1	–0.01	–0.36	–1.0	–0.14
α=10, β=1	–0.13	–0.73	–0.9	–0.51
α=10, β=10	–0.59	–0.39	–0.4	–0.31

Source: Author's calculations based on equations A1 through A6. Theoretical coefficient, λ, is shown in equation A7. Biases are calculated for univariate regressions of NPF on NOF in which all shock variances except one are assumed to be 0.

coefficient is COV(NPF,NOF)/VAR(NOF), where COV denotes covariance and VAR denotes variance. Table A1 displays the biases calculated by assuming that all shocks except one have variance of 0. It also displays the true structural coefficient, λ, based on equation A7. The second column of table A1 shows the expected bias when u1 is the only shock; the third column shows the expected bias when u2, u4, or u5 is the only shock, and the final column shows the bias when u3 is the only shock. NOF, NPF, and CAB are expressed in percentage points of GDP; RER is in logarithmic percentage points; and RR and RR* are in percentage points.

Table A1 is based on assumed values of $\gamma = .25$ and $\delta = 2$. The assumed value of γ is consistent with a trade price elasticity of 1 and exports and imports each equal to 25 percent of GDP. The assumed value of δ reflects a monetary response to a nominal spending shock roughly consistent with the original rule of Taylor (1993) scaled up to be consistent with a period length of about five years.[23] The results are not sensitive to plausible variations in the assumed values of γ and δ.

23. In Taylor's rule, the real interest rate rises by 0.5 times the shock to nominal GDP. However, that is based on an annual rate of interest. The equivalent for a 5-year return would be 2.5, but that is scaled back modestly to reflect some decay in the effect within the five-year period.

The true value of λ, shown in the first column, is bounded between 0 and –1. More efficient financial markets, which are associated with larger values of β, imply values of λ closer to –1. For any given value of β, a more aggressive response of NOF to RER (larger α) pushes λ toward 0.

The second column shows that the bias is small when the dominant shock is that to NOF, u1, and NOF does not respond much to RER (α is small). This is close to the case of exogenous NOF, in which it is well known that the regression coefficient is unbiased.

The third column shows that the bias resulting from financial shocks is always negative and often large. Note that all the financial shocks introduce the same bias. With financial shocks, it is difficult to disentangle the negative response of NOF to NPF from the negative response of NPF to NOF. The importance of private financial shocks as a source of downward bias in estimating λ is apparent in the regression estimates that do not use fitted values of NOF from first-stage regressions.

The final column shows that the bias from trade shocks, u3, may be large and positive when financial markets are efficient and NOF is close to being exogenous (α is small). Under these conditions, trade shocks are being financed largely by NPF but NOF also moves in the same direction. Because the NOF movement is small relative to NPF, the implied coefficient is large. However, when NOF responds strongly to RER, this bias can turn negative, as NOF more than fully finances the trade shock and NPF actually moves in the opposite direction.

APPENDIX 2: DATA SOURCES AND DEFINITIONS

SOURCES

IMF, *International Financial Statistics* (IFS); IMF, *World Economic Outlook* (WEO); IMF (2012) External Balance Assessment (EBA); United Nations, *World Population Prospects* 2010 (UN); World Bank, *World Development Indicators* (WDI); Norway, Ministry of Finance; and Singapore, Ministry of Finance. Updated data on capital controls based on Quinn (1997), Chinn and Ito (2006), and Schindler (2009) were obtained from staff at the IMF.

VARIABLES

Five-Year Averages: Missing observations are allowed in either the first or last year of each five-year period, but if any of the middle three years is missing the five-year period is set as missing.

Endogenous Variables

NOF: The sum of reserves and related items and other monetary and government flows from the balance of payments section of IFS except for Norway and Singapore. For Norway I add flows to the pension fund from the Norwegian finance ministry. For Singapore I replace the BOP data with gross acquisition of financial assets by the government of Singapore. (These data may include some claims on domestic assets, but the vast majority are foreign assets and the cumulated total corresponds well to estimates of the total foreign holdings of Singapore's sovereign wealth funds (Truman 2011).) I exclude from the sample all other countries that are known to have significant sovereign wealth funds that are not reported in official reserves (Bahrain, Brunei, Kuwait, Oman, Saudi Arabia (before 2005), Qatar, and United Arab Emirates). Also excluded are other monetary flows for the years 2007–10 for the United States and for countries that had dollar swap lines with the United States during the recent crisis. These dollar swaps represent matched purchases and forward sales of dollars and thus do not create any net change in currency positions of the official sector (ratio to GDP).

NPF: The sum of capital and financial accounts minus NOF (IFS, ratio to GDP).

CAB: The current account balance (IFS, ratio to GDP).

Exogenous Variables, X

There are different sets of X variables for the 40-country and 115-country datasets. Most of the concepts are the same, but the sources differ.

NPFA: Net private foreign assets is net foreign assets (NFA) minus official assets (OFFASSET) plus EXTPUBDEBT. The lagged value is used (ratio to GDP).

FISCAL: General government net lending (ratio to GDP) from IFS and WEO, including historical data from Chinn and Ito (2008). To remove endogeneity, it is regressed against the output gap and only the residual is used. For the 40-country regressions, the output gap is taken from EBA. For the 115-country regressions the output gap is constructed as the deviation between log real GDP and a centered 11-year moving average of log real GDP using the WEO forecast through 2015.

YPPP(1): Log ratio of per capita GDP in PPP terms to the US level from EBA dataset. The lagged value is used in 40-country regressions.

YPPP(2): Log ratio of per capital GDP in PPP terms to the US level from WEO dataset. The lagged value is used in 115-country regressions.

YFORE: Forecast of GDP growth five years ahead. Used in the 40-country regressions (EBA).

YGROW: Average GDP growth rate over previous five years. Used in the 115-country regressions (WEO).

HEALTH: Public health spending, lagged. Used only in the 40-country regressions (EBA, ratio to GDP).

AGING(20): Projected change in old age dependency ratio 20 years out. Used in the 40-country regressions (EBA).

AGING(10): Actual or projected change in old age dependency ratio 10 years out. Used in the 115-country regressions (UN).

ENERGY: Net energy exports (WDI, ratio to GDP).

CAPCON: A measure of controls on capital flows based on Quinn (1997) updated. Ranges from 0, for no controls, to 1, for extreme prohibition of private capital flows. For 115-country sample I used the measure of Chinn and Ito (2006) updated, which was available for more countries. For some trial regressions, I used data from Schindler (2009) updated.

Exogenous Variables, Z

There are two sets of Z variables.

The "between" set includes a full set of country dummies, a set of country dummies interacted with the lagged ratio of official foreign assets to imports (OFFASSET_M), and net exports of energy (share of GDP) for countries and years in which there was an official natural resource export reserve fund (OIL_SWF). For countries with less than four observations in the five-year data or 10 observations in the annual data, the OFFASSET_M term is dropped.

The "within" set includes the lagged ratio of official assets to imports (OFFASSET_M), the lagged interaction of the ratio of official assets to imports and the ratio of PPP per capita GDP to the US level (OFFASSM_RELPPP), the lagged five-year moving average of repayments of IMF credit as a share of

GDP (FUNDPAYMA), the lagged interaction of the ratio of official assets to imports and the five-year moving average of repayments of IMF credit as a share of GDP (OFFASSM_FUNDPAYMA), the lagged ratio of short-term external debt to GDP (EXTSTDEBT), the lagged ratio of public and publicly guaranteed external debt to GDP (EXTPUBDEBT), the lagged ratio of net official assets to GDP (NOFA), and OIL_SWF.

FUNDPAY: This variable equals zero unless use of Fund credit (from IFS) is negative (repayment) in which case it is the absolute value of use of Fund credit (ratio to GDP).

EXTSTDEBT: External short-term debt (WDI, ratio to GDP, lagged, missing values (advanced economies) set to zero).

EXTPUBDEBT: External public and publicly guaranteed debt (WDI, ratio to GDP, lagged, missing values (advanced economies) set to zero).

OIL_SWF: Net energy exports for Libya and Saudi Arabia in all years plus Norway starting in 1990, Azerbaijan starting in 1999, Algeria and Kazakhstan starting in 2000, and Russia starting in 2004. SWF start dates are based on Truman (2011).

Other Variables

ERR: Errors and omissions in the BOP (IFS, ratio to GDP).

NFA: Net foreign assets is taken from the EBA dataset for the 40-country sample. For the 115-country sample it is taken from IFS (net international investment position) and spliced with data from Lane and Milesi-Ferretti (2007) for earlier observations that are missing in IFS provided that the Lane and Milesi-Ferretti data are within 20 percentage points of GDP of the IFS data in the first year of overlap.

NOFA: Net official foreign assets is OFFASSET minus EXTPUBDEBT.

OFFASSET: Foreign exchange reserves ratio to GDP from IFS, except for Norway and Singapore. For Norway it includes the value of the pension fund. For Singapore it is based on the perpetual inventory method using NOF and the Government of Singapore's gross financial assets as of March 2010.

M: Imports of goods and services from IFS.

GDEBT: Gross general government debt from WEO.

Country Samples

40 Countries: Argentina (AR), Australia (AL), Brazil (BR), Canada (CA), Chile (CL), China (CN), Colombia (CO), Costa Rica (CR), Czech Republic (CZ), Denmark (DK), Egypt (EG), euro area (EA), Guatemala (GT), Hungary (HU), India (IN), Indonesia (ID), Israel (IS), Japan (JP), Korea (KO), Malaysia (MA), Mexico (MX), Morocco (MO), New Zealand (NZ), Norway (NO), Pakistan (PK), Peru

(PE), Philippines (PH), Poland (PL), Russia (RU), Singapore (SG), South Africa (ZA), Sweden (SD), Switzerland (SZ), Sri Lanka (SL), Thailand (TH), Tunisia (TN), Turkey (TU), United Kingdom (UK), United States (US), and Uruguay (UR).

115 Countries: Above minus euro area, plus Albania, Algeria, Armenia, Austria, Azerbaijan, Bahrain, Bangladesh, Belarus, Belgium, Benin, Bolivia, Bosnia and Hercegovina, Botswana, Bulgaria, Cambodia, Cameroon, Republic of Congo, Cote d'Ivoire, Croatia, Cyprus, Dominican Republic, El Salvador, Estonia, Ethiopia, Finland, France, Gabon, Georgia, Germany, Ghana, Greece, Haiti, Honduras, Hong Kong, Iceland, Ireland, Italy, Jamaica, Jordan, Kazakhstan, Kenya, Kyrgyz Republic, Latvia, Lebanon, Libya, Lithuania, Macedonia, Malta, Moldova, Myanmar, Namibia, Nepal, Netherlands, Nicaragua, Panama, Paraguay, Portugal, Romania, Saudi Arabia, Senegal, Slovak Republic, Slovenia, Spain, Sudan, Syria, Tajikistan, Tanzania, Togo, Trinidad and Tobago, Ukraine, Venezuela, Vietnam, Yemen, and Zambia.

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