The Predictive Information Content of External Imbalances for Exchange Rate Returns: How Much Is It Worth?*

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Abstract

This paper examines the exchange rate predictability stemming from the equilibrium model of international financial adjustment developed by Gourinchas and Rey (2007). Using predictive variables that measure cyclical external imbalances for country pairs, we assess the ability of this model to forecast out-of-sample four major US dollar exchange rates using various economic criteria of model evaluation. The analysis shows that the model provides economic value to a risk-averse investor, delivering substantial utility gains when switching from a portfolio strategy based on the random walk benchmark to one that conditions on cyclical external imbalances.

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1 Introduction

Exchange rate movements are a major source of risk to a number of economic agents and, not surprisingly, understanding the determinants of exchange rate fluctuations continues to draw serious consideration among academics, policy makers and practitioners. The foreign exchange (FX) market is also the largest financial market, with a daily turnover exceeding three trillion US dollars, a third of which is in spot transactions (Bank for International Settlements, 2007). Unfortunately, attempts to explain and forecast exchange rates using either economically meaningful variables or sound theoretical models have generally met with limited success. While a few papers find some evidence of predictability using macro variables at long horizons (Mark, 1995; Abhyankar, Sarno and Valente, 2005), the conventional wisdom is that economic fundamentals are of little use and exchange rates are well approximated by a naïve random walk model, at least at horizons shorter than one year (Meese and Rogoff, 1983; Engel, Mark and West, 2008; Rogoff and Stavrakeva, 2008).

The challenge to relate exchange rates to economic fundamentals has recently received an important development with the model of international financial adjustment of Gourinchas and Rey (2007), hereafter GR.[1] The model gives useful insights on the sustainability of the high current account deficits experienced in the last decade by the US, highlighting the role that valuation effects in the US net foreign asset position might have in relaxing its external constraint. The implication of the model we focus on is that a suitably constructed measure of US cyclical external imbalances – which GR term nxa – should be linked to future movements in the US dollar exchange rate. GR provide empirical support in favor of this prediction using data for the US dollar effective exchange rate, both in-sample and out-of-sample.

The promise of the simple structural model of GR to forecast exchange rate returns deserves careful empirical examination, and this paper provides a measure of its worth. We move beyond assessing predictability from a purely statistical perspective and provide evidence on whether the predictive information in *nxa* is economically significant. To this end, we assess the economic value of exchange rate predictability originating from *nxa* relative to the random walk benchmark, in the context of a stylized dynamic asset allocation strategy. Specifically, in a mean-variance framework, we study the problem of a US investor who manages a dynamically rebalanced portfolio by allocating his wealth to a domestic bond and four foreign bonds (for Canada, Germany, the UK and Japan). We compare the out-of-sample performance of a benchmark portfolio strategy based on the random walk relative to a portfolio strategy that exploits the predictive information in *nxa*. The economic assessment uses a utility-based criterion to compute the performance fee that a risk-averse investor with quadratic utility would be willing to pay to switch from the benchmark strategy to the alternative strategy conditioning on *nxa*. In addition, we employ the performance measure recently proposed by Goetzmann, Ingersoll, Spiegel and Welch (2007), which assumes neither a specific utility function nor a specific distribution of portfolio returns. Also, we consider the impact of transaction costs and real-time data on the above performance measures. In short, we provide an economic test of the predictive power of *nxa*.

The emphasis on economic evaluation of the predictive power of *nxa* requires moving to a set of bilateral exchange rates, while GR carry out their empirical work using data for the US effective exchange rate. This is important because bilateral exchange rates are the prices of the traded assets that are relevant to an investor. Hence, bilateral predictive variables are needed to assess the predictive power of the information content in *nxa* in the context of portfolio choice.[2] As predictive variables, we use empirical proxies for bilateral external imbalances between the US and other major countries (instead of using a single measure of US global external imbalances). Using data at the quarterly frequency from 1973 to 2007 for four major US dollar exchange rates, the construction of the bilateral external imbalances follows GR but requires some amendments when one moves away from the US effective exchange rate. We construct these measures using an updated version of the data set compiled by Lane and Milesi-Ferretti (2007) on foreign assets and liabilities.[3]

To anticipate our main results, the empirical analysis provides robust evidence that bilateral external imbalances have strong predictive ability for exchange rate returns both in-sample and out-of-sample, on the basis of several performance measures. We find large economic value to an investor who allocates capital internationally simply using the predictive information in *nxa*. Specifically, the evidence shows that the economic value of *nxa* is larger than the economic value obtainable from trading on the basis of the random walk benchmark. We conclude that *nxa* captures information about future exchange rate movements during the recent floating period, as one would expect from a state variable that summarizes the expectations of rational economic agents about future exchange rate returns. This result is very encouraging, given the evidence provided by a vast body of literature on exchange rates that the state of the economy is not related in a meaningful fashion to short-run fluctuations in exchange rates.

The remainder of the paper is organized as follows. In the next section we briefly review the relevant literature on exchange rate predictability conditioning on fundamentals, and describe the essence of GR. We also discuss the empirical extension of this model for bilateral exchange rate predictability. Section 3 describes the data and reports the estimation results for regressions that investigate the predictive power of *nxa* for exchange rate returns at various horizons. Section 4 outlines the framework for assessing the economic value of exchange rate predictability for a risk-averse investor with a dynamic portfolio allocation strategy. Section 5 reports the empirical results for the economic value analysis. Finally, Section 6 concludes. In the Appendix, we provide details on the real-time data set and on bootstrap methods.

2 Exchange Rates and Fundamentals

In this section, we briefly review the current state of the literature on fundamentals and exchange rate predictability before presenting the model of international financial adjustment developed by GR and its empirical extension to bilateral exchange rates.

2.1 Stylized Facts and Exchange Rate Predictability

Economic fundamentals can generally explain at most a small part of nominal exchange rate changes (Kilian, 1999; Berkowitz and Giorgianni, 2001; Sarno, 2005; Engel, Mark and West, 2008). There are a number of explanations for this apparent "disconnect" puzzle. They include, *inter alia*, the recognition that in a present-value asset-pricing framework the exchange rate would follow a process very close to a random walk if at least one predictive variable has a unit root and the discount factor is close to unity (Engel and West, 2005); the failure of standard linear predictive regressions to capture the presence of parameter instability (e.g. Rossi, 2005, 2006; Sarno and Valente, 2009); the role of transaction costs (Obstfeld and Rogoff, 2001); the presence of higher-order expectations and information heterogeneity (Bacchetta and van Wincoop, 2006); and the general issue of omitted fundamental variables (e.g. GR).

2.2 International Financial Adjustment and Exchange Rates

Starting from a country's intertemporal budget constraint, suitably adjusted for slow-moving structural changes, GR show that current external imbalances must predict either future net export growth or future returns on the net foreign asset portfolio, or both. Since the exchange rate plays a critical role for both future net exports and future returns on external assets and liabilities, it follows that today's imbalances contain valuable information about future exchange rate returns. Intuitively, depreciation of the domestic currency contributes to the process of international adjustment through future trade surpluses. This is the *trade channel*, suggested by the traditional approach to the current account (Obstfeld and Rogoff, 2007). However, the external adjustment can also take place through a different mechanism since a domestic currency depreciation may increase the value of foreign assets (denominated in foreign currency) relative to foreign liabilities (denominated in domestic currency). This change in net foreign portfolio returns causes a net wealth transfer, thus contributing to external adjustment via the *valuation channel*.[4]

To clarify these implications, consider the external budget constraint of a country between time t and $t+1$:

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

where NA_t denotes net foreign assets, defined as external assets minus external liabilities; NX_t is net exports, defined as the difference between exports and imports of goods and services; and R_{t+1} is the gross return on the net foreign asset portfolio, a combination of the gross return on assets and the gross return on liabilities. The accumulation identity (1) simply states that the net foreign asset position improves with positive net exports and with the return on the net foreign asset portfolio.

To investigate the implications of the external budget constraint, exports, imports, external assets and liabilities are normalized relative to domestic wealth, and adjusted for slow-moving trends attributed to structural changes in the world economy such as financial and trade integration. Under fairly general assumptions, the first-order approximation of equation (1) around its trend satisfies:

$$nxa_{t+1} \approx \frac{1}{\rho} nxa_t + r_{t+1} + \Delta nx_{t+1}. \tag{2}$$

The term nxa_t is a linear combination of stationary components of (log) exports, imports, foreign assets and liabilities relative to domestic wealth, and incorporates information from both the trade balance (the flow) and the foreign asset position (the stock). It represents a theoretically-motivated measure of *cyclical external imbalances* that increases with foreign assets and exports and decreases with foreign liabilities and imports. The discount factor ρ depends on the steady-state average ratio of net exports to the net foreign assets. The component r_{t+1} is the real return on net foreign assets, which increases with the return on foreign assets and declines with the return on foreign liabilities. The term Δnx_{t+1} denotes detrended net export growth between t and $t+1$, which increases with cyclical export growth and decreases with cyclical import growth. Equation (2) suggests that a country can enhance its net foreign asset position either via a trade surplus ($\Delta nx_{t+1} > 0$) or via high returns on its net foreign asset portfolio ($r_{t+1} > 0$).

The next step defines the intertemporal external budget constraint. Under the assumption that the economy settles into a balanced-growth path, GR solve forward equation (2) and obtain the following intertemporal external constraint in deviation from its trend:

$$nxa_t \approx -\sum_{j=1}^{+\infty} \rho^j \left(r_{t+j} + \Delta nx_{t+j}\right) \tag{3}$$

which requires the no-Ponzi condition that nxa_t cannot grow faster than the steady state growth-adjusted interest rate.[5] Since equation (1) is an identity, equation (3) must hold both ex-post and ex-ante along every sample path, implying that it will also hold in expectation:

$$nxa_t \approx -\sum_{j=1}^{+\infty} \rho^j E_t \left(r_{t+j} + \Delta nx_{t+j}\right). \tag{4}$$

This equation plays a critical role in this model of international financial adjustment. It shows that time-variation in nxa must forecast either future portfolio returns or future net export growth, or both. Consider, for instance, a country with either a cyclical trade deficit or a cyclical debt position or both. In this case, a negative value of nxa anticipates not only future trade surpluses ($E_t \Delta nx_{t+j} > 0$), but also an increase in future returns on net foreign assets

$(E_t r_{t+j} > 0)$. The former effect, the *trade channel*, is a standard implication of the intertemporal approach to the current account. The latter effect is the *valuation channel* and represents the key mechanism of GR.

Exchange rate predictability is a natural implication of this mechanism of financial adjustment. For example, if foreign assets are entirely denominated in foreign currency, and foreign liabilities are entirely denominated in domestic currency, then the real return on the net foreign portfolio between time t and $t+1$ can be written as

$$r_{t+1} = |\mu^a| \left(r^{*a}_{t+1} + \Delta s_{t+1} \right) - |\mu^l| r^l_{t+1} - \pi_{t+1} \tag{5}$$

where r^{*a}_{t+1} is the nominal return on foreign assets in foreign currency; Δs_{t+1} is the log-change in the nominal exchange rate (defined as the domestic price of the foreign currency); r^l_{t+1} is the nominal return on foreign liabilities in domestic currency; π_{t+1} is the realized domestic inflation rate; and μ^a and μ^l are the (trend) share of assets and liabilities in the net foreign asset portfolio, respectively. If the local currency return is assumed to be constant, a currency depreciation increases the domestic return on foreign assets. This negative correlation between nxa_t and future exchange rate movements is further amplified by the degree of leverage of the net foreign asset holdings when $|\mu^a| > 1$.

In brief, a combination of exports, imports, external assets and liabilities can capture the expectations of rational agents about future exchange rate movements. A positive value of nxa predicts a future currency appreciation, whereas a negative value anticipates a future currency depreciation.

2.3 Extension to Bilateral Exchange Rates

In GR, nxa is constructed using aggregate exports, imports, foreign assets and liabilities, and is shown to contain significant out-of-sample forecasting power at horizons from 1 to 16 quarters for two series of multilateral nominal exchange rates: the foreign direct investment (FDI)-weighted effective exchange rate, and the Federal Reserve trade-weighted effective exchange rate for the US dollar against major currencies. We refer to this definition of nxa as the 'global' measure of cyclical external imbalances.[6] In the context of this paper, a 'bilateral' measure of cyclical external imbalances is desirable because effective exchange rates are not tradable assets. Investors form expectations and allocate their wealth on the basis of bilateral exchange rates, since these are the prices they observe and which impact on their portfolio returns.

However, a bilateral measure of cyclical global imbalances is not directly observable since data on a bilateral basis are generally not available. One might be tempted to use global nxa as a proxy for the unobservable bilateral nxa. We argue that this practice may not be entirely appropriate since global nxa captures not only information related to the bilateral exchange rate of interest but also about other trading partners. In essence, global nxa, if used as predictive variable in a regression for bilateral exchange rate returns, would cause an errors-in-variable problem, potentially leading to inconsistent least squares estimates.

An important caveat is in order at this point. The GR analysis is valid at the aggregate level for the effective exchange rate since it starts from a country's intertemporal budget constraint. As there is no bilateral budget constraint, the adaptation of the GR analysis to a bilateral context raises conceptual issues. Specifically, it is clear that in an N-country ($N > 2$) world the budget constraint does not need to hold bilaterally but only on aggregate. For example, a country could run a very persistent deficit with another country, as long it runs a similar-size surplus with other economies. It is easy to think of examples where the use of bilateral measures of external imbalances may be problematic. Consider the currency of a country with an approximately balanced external position, for example the euro. This would imply that the intertemporal budget constraint should have no impact on the exchange rate. However, this country is likely to have negative and positive positions with individual trading partners. The empirical analysis based on bilateral measures of external imbalances would imply that these positions should affect the bilateral exchange rate, but this is not implied by the budget constraint given that the country is in a balanced external position on aggregate.[7]

To summarize, on the one hand, the theory has clear implications about the predictive power of global nxa for the effective exchange rate, with the information content of the predictive power stemming from the intertemporal budget constraint. On the other hand, the theory has no clear implications for bilateral exchange rates, which are the traded assets investors care about and form expectations of. Adapting the GR framework to a bilateral setting prevents us from being able to state forcefully that the information content in bilateral nxa is necessarily linked to the budget constraint. Regardless of these conceptual issues, we use a bilateral measure of cyclical external imbalances in the core empirical analysis. We argue that an empirically-based bilateral nxa that is derived from global nxa may well capture part of the information content stemming from the budget constraint, i.e. only the subset of the information content that is related to the country pair whose exchange rate we are interested in. Put another way, this empirically-based bilateral nxa has a weaker theoretical justification than global nxa, but we demonstrate below that it is empirically superior to global nxa, presumably because it mitigates the errors-in-variable problem that arises when using global nxa to predict a bilateral exchange rate.

Ultimately, we aim at estimating the following predictive regression:

$$\Delta_k s_{t+k}^{(i)}/k = \alpha + \beta nxa_t^{(i)} + \varepsilon_{t+k} \tag{6}$$

where $s_t^{(i)}$ is the log-nominal exchange rate at time t, defined as the domestic price of foreign currency i; $\Delta_k s_{t+k}^{(i)} = s_{t+k}^{(i)} - s_t^{(i)}$ is the nominal exchange rate return between time t and $t+k$; and $nxa_t^{(i)}$ is the bilateral measure of cyclical external imbalances between the domestic economy and the foreign country i at time t. In our setting the US is the domestic economy. Since data on bilateral external assets and liabilities are not available, we can directly measure nxa_t (the global measure of cyclical external imbalances) but not $nxa_t^{(i)}$ (the bilateral measure of cyclical external imbalances between the domestic economy and foreign economy i). To overcome this problem, we proceed with an instrumental variables (IV) estimator in two steps. In the first step, nxa_t for the domestic economy is regressed on a set of instruments. In the second step, the fitted value from the first-step regression is used as a proxy for $nxa_t^{(i)}$ in regression (6), which is estimated by ordinary least squares.

The IV method requires, however, a set of instruments that are correlated with domestic global nxa_t but uncorrelated with the measurement error, i.e. uncorrelated with the external position of the domestic economy versus other countries. We consider two instruments. The first candidate is the global nxa_t for the foreign country i, which obviously must contain the same information between the domestic economy and the foreign country i as the global nxa_t for the domestic economy. As an additional instrument, we use the bilateral detrended net exports $nx_t^{(i)}$ between the domestic economy and the foreign economy i, constructed as a linear combination of the stationary components of (log) bilateral exports and imports to wealth ratios. We provide evidence on the validity of these instrumental variables in the empirical analysis using a Sargan test statistic.

As an illustrative example, suppose we want to predict the nominal exchange rate between the US dollar and the British pound. First, we regress the US global nxa_t on a constant term, the UK global nxa_t, and the bilateral detrended net exports between the US and the UK. Second, we use the fitted value from this contemporaneous regression as the predictive variable in regression (6), where $\Delta_k s_{t+k}^{(i)}$ is the k-period nominal exchange rate return between the US dollar and the British pound.

3 Empirical Results

3.1 Data and Descriptive Statistics

The data set consists of quarterly observations ranging from 1973Q1 to 2007Q4, and comprises four spot exchange rates relative to the US dollar (USD): the Canadian dollar (CAD), the Deutsche mark/euro (EUR), the British pound (GBP) and the Japanese yen (JPY). These data are obtained from the International Monetary Fund's *International Financial Statistics* (*IFS*) database. In the economic evaluation exercise, we also use the Eurocurrency deposit rates with three-month maturity obtained from *Datastream* as a proxy for the riskless rate.

Turning to the macroeconomic data, we obtain annual data on foreign assets and liabilities for the US, Canada, Germany, the UK and Japan from Lane and Milesi-Ferretti (2007); seasonally unadjusted quarterly data on exports and imports of goods and services from the *IFS* database (Canada, Germany and Japan), the *UK National Statistics*, and the *US Bureau of Economic Analysis* (*BEA*); seasonally unadjusted quarterly data on bilateral exports and imports of goods and services between the US and each of Canada, Germany, the UK and Japan from *BEA*.[8] As proxy for domestic wealth, we collect annual data on persons and unincorporated business net worth from *Statistics Canada*; annual data on household fixed assets from the *Federal Statistics Office of Germany*; annual data on household net worth from *Japan Statistics Bureau*; quarterly data on households and non-profit organizations net worth from *Flow of Funds of the United States*; and annual data on household and non-profit institutions net worth from the *UK National Statistics*. We seasonally adjust the data on exports and imports using dummy-variable regressions, and construct quarterly observations from annual data on assets, liabilities, and net worth by linear interpolation. In the out-of-sample analysis, however, to avoid any look-ahead bias we recursively seasonally adjust the exports and imports series and use linear extrapolation for assets, liabilities, and net worth.

Table 1 reports the descriptive statistics for quarterly percent changes in (log) external assets Δa_t, external liabilities Δl_t, exports Δx_t, and imports Δm_t, the global measure of cyclical external imbalances nxa_t, the bilateral measure of cyclical external imbalances $nxa_t^{(i)}$, and the nominal exchange rate return $\Delta s_t^{(i)}$. The global measure of cyclical external imbalances, nxa_t is defined as a linear combination of detrended (log) exports, imports, foreign assets, and liabilities relative to domestic wealth.[9] The bilateral measure of cyclical external imbalances between the domestic country and a foreign country i, $nxa_t^{(i)}$ is constructed as described in the previous section. In our setting, the US is the domestic country while Canada, Germany, the UK and Japan are the foreign countries. As one would expect, foreign assets and liabilities show lower volatility and higher serial correlation than exports and imports. For the sample period investigated, nxa_t has a sample mean of zero, a large standard deviation and high serial correlation. Comparable properties are displayed by $nxa_t^{(i)}$. Finally, the exchange rate returns present sample means close to zero, a standard deviation ranging between 2.677% and 6.010%, and very low serial correlation.

3.2 Data Comparison with GR

Before investigating the predictive ability of the bilateral measures of US cyclical external imbalances, it is important to notice that our data source of aggregate exports, imports, external assets and liabilities for the US differs from GR. However, our measure of nxa_t has comparable properties to the measure used by GR. This similarity is visually clear in Figure 1, which plots three time series for nxa_t: (i) the original time series of nxa_t used by GR based on quarterly data ranging from 1952Q1 to 2004Q1; (ii) the time series of nxa_t based on the same data employed by GR but constructed using only data from 1973Q1 to 2004Q1 in order to match the start date of the sample period in this paper; (iii) and our time series of nxa_t using quarterly data from

1973Q1 to 2007Q4. The three time series, which are normalized to have zero means and unit standard deviations, co-move strongly throughout the sample, with correlations of about 80%.

Moreover, to ensure that our data set is comparable to GR, we carry out a preliminary exercise by estimating the predictive regression:

$$\Delta_k s_{t+k}/k = \alpha + \beta nxa_t + \varepsilon_{t+k} \tag{7}$$

where s_t is the log-nominal effective exchange rate (NEER) of the US dollar at time t; $\Delta_k s_{t+k} = s_{t+k} - s_t$; the horizon k ranges from 1 quarter to 16 quarters; and nxa_t is the US aggregate cyclical external position at time t. The US NEER is the trade-weighted exchange rate from the *IFS* database. The results (not tabulated to conserve space) suggest that the estimates of β have the expected negative sign and are statistically significant at all horizons, although the magnitude tends to be slightly smaller than in GR. The R^2 increases with k, peaking at $k = 8$ (2-year horizon) where it reaches 43%, before declining to 26% for $k = 16$ (4-year horizon). We also assess the out-of-sample performance of nxa_t by evaluating whether the predictive regression (7) has a significantly lower mean squared error (MSE) than the driftless random walk model. We employ the Clark and West (2007) MSE-adjusted statistic for the null hypothesis of equal MSE between the competing models, using forecasts based on a 20-year rolling window and calculating the one-sided p-value for the statistic by bootstrap.[10] The results confirm the out-of-sample forecast accuracy of nxa_t first documented by GR.

3.3 Extension to Bilateral Exchange Rates

This section documents the in-sample predictive power of the bilateral measures of US cyclical external imbalances (as opposed to aggregate) on bilateral exchange rate returns (as opposed to effective). We proceed using the framework described in Section 2.3. First, we regress the US aggregate nxa on a constant term, the foreign aggregate nxa, and the bilateral detrended net exports between the US and the foreign country. Second, the fitted value from this regression is used as the bilateral measure of cyclical external imbalances between the US and the foreign country in the predictive regression (6) to forecast the k-period ahead nominal exchange rate return between the US dollar and the foreign currency.

Table 2 displays the estimation results for the predictive regression (6), where $nxa_t^{(i)}$ is the bilateral measure of external imbalances for the US relative to Canada, Germany, the UK and Japan, respectively; $\Delta_k s_{t+k}^{(i)}$ is the k-period nominal exchange rate return for CAD, EUR, GBP and JPY, respectively; and the horizon k ranges from 1 quarter to 16 quarters. We also report in Table 2 the results from carrying out a Sargan test for the null hypothesis of valid instruments (overidentifying restrictions). These tests confirm the validity of the set of instruments used in the first-stage regression that generates our proxy for bilateral external imbalances, with p-values ranging from 0.123 to 0.980.

The estimated coefficients on $nxa_t^{(i)}$ are generally negative, as expected. The empirical evidence is particularly strong for EUR, where the coefficients are large in magnitude and strongly statistically significant. For JPY the predictive power of $nxa_t^{(i)}$ is statistically significant up to 2 years ahead at the 1% significance level (or up to 3 years ahead at the 10% significance level), whereas for CAD statistical significance is established at least at the 5% level from 1 year onwards. The results are slightly weaker for GBP, where the coefficient on $nxa_t^{(i)}$ is only significant for horizons longer than 2 years. Moreover, while the predictive power of external imbalances decreases at longer horizons for JPY, the evidence is reversed for CAD, EUR and GBP.

Figure 2 reports the exchange rate returns and the bilateral cyclical imbalances for each country in our sample, for $k = 1$. The dotted lines represent quarterly exchange rate returns, and the solid lines are the lagged measures of bilateral external imbalances. Notice that the time series are standardized to have zero means and unit standard deviations. The graphs provide a visual illustration of the general negative co-movement between exchange rate returns and the lagged bilateral measures of external imbalances. This co-movement becomes even clearer when aggregating the time series of exchange rate returns at annual frequency (for $k = 4$), as shown in Figure 3.

Overall, the empirical results in this section extend the validity of the GR model to bilateral exchange rates when bilateral measures of cyclical external imbalances are employed. We now turn to the analysis of the economic value of the predictive power of $nxa_t^{(i)}$ since statistical evidence of predictability does not necessarily imply economic significance (Leitch and Tanner, 1991; Elliott and Ito, 1999; Della Corte, Sarno and Thornton, 2008).

4 Economic Value: The Setting

In this section, we describe the framework used to examine the economic significance of models that condition on bilateral measures of cyclical external imbalances.

4.1 The Dynamic FX Strategies

We consider a US investor with a quarterly rebalancing period who builds a portfolio by allocating his wealth between the domestic bond (US) and four foreign bonds (Canada, Germany, the UK and Japan). The domestic and foreign riskless assets are proxied by three-month Eurocurrency deposits. The yield of the foreign bonds is riskless in local currency but risky when expressed in domestic currency. Indeed, the return a US investor enjoys from investing in a foreign bond between t and $t + 1$ is equal to the foreign riskless return known at time t adjusted by the exchange rate return observed at time $t + 1$. This implies that at time t, the only risk the US investor is exposed to is FX risk.

Each period the investor takes two steps. First, he uses the model that conditions on $nxa_t^{(i)}$ to forecast the one-period ahead exchange rate returns. Note that the investor does not model the dynamics of the conditional covariance matrix of exchange rate returns, but simply uses the unconditional covariance matrix at time t to forecast the covariance matrix for the next period. Second, using these forecasts, the investor dynamically rebalances his portfolio by computing new optimal portfolio weights based on a mean-variance strategy. As a benchmark model, we use the driftless random walk, which is equivalent to setting $\alpha = \beta = 0$ in the predictive regression (6). It follows that the conditional expectation of exchange rate returns is equal to zero, consistent with the majority of studies in the literature since Meese and Rogoff (1983).

The main goal of this setting is to determine whether the model conditioning on the bilateral measures of US cyclical imbalances is economically superior to the naïve random walk benchmark. It is important to note that the asset allocation exercise does not use data in real time, although it is well known that economic data are generally subject to release delays and revisions over time. Moreover, the exchange rate used in the asset allocation is not a transaction price and does not allow for the bid-ask spread, hence ignoring transaction costs. Therefore, we do not claim that a real-world investor acting on the predictive information in nxa would have gained exactly the returns reported here. Our objective is not to design an executable asset allocation strategy, but to measure the economic significance of the information content in external imbalances for the purpose of forecasting exchange rates, as a complement to the statistical analysis reported earlier. However, we investigate to some extent the robustness of our results to transaction costs and the use of real-time data later in the paper.

4.2 Mean-Variance Dynamic Asset Allocation

Mean-variance analysis is a natural framework to evaluate the economic performance of an asset allocation strategy. We consider an investor who dynamically rebalances his portfolio every quarter by maximizing expected portfolio returns while achieving a desired portfolio volatility. This maximum return strategy leads to a portfolio allocation on the efficient frontier. The dynamic portfolio weights are computed by implementing the maximum return strategy using the forecasts of the conditional mean and conditional variance-covariance matrix. Let r_{t+1} denote the $N \times 1$ vector of risky asset returns; $\mu_{t+1|t} = E_t[r_{t+1}]$ is the conditional expectation of r_{t+1}, and $\Sigma_{t+1|t} = E_t[(r_{t+1} - \mu_{t+1|t})(r_{t+1} - \mu_{t+1|t})']$ is the conditional variance-covariance matrix of r_{t+1}. At each period t, the investor solves the following problem:

$$\begin{aligned} &\max_{w_t} \left\{ \mu_{p,t+1|t} = w_t' \mu_{t+1|t} + (1 - w_t' \iota) r_f \right\} \\ &s.t. \quad (\sigma_p^*)^2 = w_t' \Sigma_{t+1|t} w_t \end{aligned} \tag{8}$$

where w_t is the $N \times 1$ vector of portfolio weights on the risky assets, ι is an $N \times 1$ vector of ones, $\mu_{p,t+1|t}$ is the conditional expected return of the portfolio, σ_p^* is the target volatility of the portfolio returns, and r_f is the domestic riskless return. The solution to this optimization problem delivers the risky asset weights

$$w_t = \frac{\sigma_p^*}{\sqrt{C_t}} \Sigma_{t+1|t}^{-1} (\mu_{t+1|t} - \iota r_f) \tag{9}$$

where $C_t = (\mu_{t+1|t} - \iota r_f)' \Sigma_{t+1|t}^{-1} (\mu_{t+1|t} - \iota r_f)$. The weight on the riskless asset is $(1 - w_t' \iota)$. The gross portfolio return at time $t+1$ is computed as

$$R_{p,t+1} = 1 + w_t' r_{t+1} + (1 - w_t' \iota) r_f = R_f + w_t' (R_t - \iota R_f) \tag{10}$$

where R_t is the $N \times 1$ vector of gross risky returns, and R_f is the gross domestic riskless return. Recall that, since we do not model the conditional covariance matrix of exchange rate returns, we simply set $\Sigma_{t+1|t} = \Sigma_t$, where Σ_t is the unconditional covariance matrix of the exchange rate returns at time t.

4.3 Performance Measures

The performance of strategies exploiting the predictive information in $nxa_t^{(i)}$ is ranked against the benchmark strategy based on the driftless random walk using a utility-based criterion. This measure reflects the close relation between mean-variance analysis and quadratic utility, which can be thought of as a second-order approximation to the investor's true utility function (Hlawitschka, 1994). Using the setting developed by West, Edison and Cho (1993) and Fleming, Kirby and Ostdiek (2001), we aim at measuring the maximum performance fee that a risk-averse investor with quadratic utility would be willing to pay to have access to the additional information available in $nxa_t^{(i)}$ relative to the benchmark random walk model.[11]

At any point in time, a model is better than a second one if investment decisions based on the forecasts of the first model lead to higher utility gains. Suppose that holding the optimal portfolio based on the random walk model (RW strategy) generates the same average utility as holding the optimal portfolio based on $nxa_t^{(i)}$ (NXA strategy) that is subject to quarterly expenses Φ. Since the investor would be indifferent between these two strategies, we interpret Φ as the maximum performance fee he will pay to switch from the RW strategy to the NXA strategy. The performance fee, expressed as a fraction of wealth invested, is computed as the value Φ that satisfies:

$$\sum_{t=0}^{T-1} \left\{ (R^*_{p,t+1} - \Phi) - \frac{\delta}{2(1+\delta)} (R^*_{p,t+1} - \Phi)^2 \right\} = \sum_{t=0}^{T-1} \left\{ R_{p,t+1} - \frac{\delta}{2(1+\delta)} R^2_{p,t+1} \right\} \qquad (11)$$

where $R^*_{p,t+1}$ is the gross portfolio return constructed using the NXA strategy, $R_{p,t+1}$ is the gross portfolio return implied by the benchmark RW strategy, and δ is the investor's constant degree of relative risk aversion (RRA). We set δ equal to 6, and report the estimate of Φ as annualized basis points (bps).

In a recent study, Goetzmann, Ingersoll, Spiegel and Welch (2007) propose a manipulation-proof performance measure defined as

$$M\left(R_p\right) = \frac{1}{(1-\delta)} \ln \left\{ \frac{1}{T} \sum_{t=0}^{T-1} \left(\frac{R_{p,t+1}}{R_f} \right)^{1-\delta} \right\} \tag{12}$$

where $M\left(R_p\right)$ is an estimate of the portfolio's premium return after adjusting for risk, and can be interpreted as the certainty equivalent of the excess portfolio returns. This is an attractive criterion since it is robust to the distribution of the portfolio returns and does not require the assumption of any particular utility function. As a complement to the performance fee Φ, we build on this criterion and consider the difference between manipulation-proof performance measures for competing portfolios as follows:

$$\Theta = M(R_p^*) - M(R_p). \tag{13}$$

We interpret Θ as the excess premium return of the NXA strategy relative to the RW strategy, and report it in annualized bps.

Finally, we also compute the Sharpe Ratio (SR), as this is arguably the most common performance measure used in financial markets. The SR is calculated for each strategy as the ratio of the average realized portfolio excess return to the standard deviation of the portfolio returns.

4.4 Transaction Costs

The impact of transaction costs is an essential consideration to evaluate the economic significance of the NXA strategy relative to the RW strategy. A precise determination of the size of transaction costs is generally difficult because it depends on several factors such as the type of investor (e.g. individual vs. institutional investor), the value of the transaction, and the nature of the broker (e.g. brokerage firm vs. direct internet trading).

In our analysis, we compute the break-even proportional transaction cost τ^{be} that renders investors indifferent between two alternative strategies (Han, 2006). We assume that transaction costs equal a fixed proportion (τ) of the value traded in each bond: $\tau \left| w_t - w_{t-1}(R_t/R_{p,t}) \right|$. In comparing the dynamic NXA strategy with the RW strategy, an investor who pays transaction costs lower than τ^{be} will prefer the NXA strategy. Since τ^{be} is a proportional cost paid every time the portfolio is rebalanced, we report τ^{be} in quarterly *bps*.

5 Economic Value: The Empirical Evidence

5.1 Core Results

The critical question we address in this section is whether a dynamic strategy conditioning on bilateral measures of US external imbalances outperforms the random walk strategy. We provide an economic evaluation of exchange rate predictability by assessing the performance of dynamically rebalanced portfolios based on the NXA strategy relative to the RW strategy. The analysis is carried out both in-sample and out-of-sample. The in-sample period uses quarterly data from 1973Q1 to 2007Q4 to estimate the predictive regression (6). The out-of-sample analysis uses a 20-year rolling predictive regression, and runs from 1993Q1 through 2007Q4. Notice that to avoid any 'look-ahead bias', we reestimate $nxa_t^{(i)}$ at each point in time using only available information. This ensures that the rolling-window forecasts are always constructed conditioning on an information set that is available at the time of the forecast.

The economic evaluation focuses on four criteria: the performance fee Φ, the excess premium return Θ, the Sharpe Ratio SR, and the break-even transaction cost τ^{be}. Each strategy uses a quarterly rebalancing period, three target annualized portfolio volatilities, $\sigma_p^* = \{8\%, 10\%, 12\%\}$, and a degree of relative risk aversion $\delta = 6$. The estimates of Φ and Θ are reported in annualized *bps*, whereas the estimates of τ^{be} are given in quarterly *bps*.

Table 3 presents the economic value results both in-sample and out-of-sample. The in-sample results show that the NXA strategy exhibits high economic value relative to the RW strategy. Consider, for example, the target volatility of $\sigma_p^* = 10\%$. The performance fee a US investor is willing to pay for switching from the RW strategy to the NXA strategy is 143 annual *bps,* whereas the premium return the NXA strategy yields in excess to the RW strategy is 136 annual *bps*. These results are also reflected in the risk-return trade-off as measured by SR. The NXA strategy delivers an SR of 0.83, larger than 0.70, which is the SR of the RW strategy.

Moreover, the out-of-sample results confirm the high economic value of the NXA strategy. This is a noticeable result, which contrasts with the weak out-of-sample evidence that characterizes the disconnect between exchange rates and fundamentals documented in the literature (e.g. Engel, Mark and West, 2008). At the target portfolio volatility of $\sigma_p^* = 10\%$, a US investor is willing to pay 230 annual *bps* for switching from the RW to the NXA strategy, which is comparable to the excess premium return of 199 annual *bps*. Similarly, the SR increases from 0.78 to 1.00 when the investor uses the NXA strategy rather than the RW strategy.

Finally, if transaction costs are sufficiently high, the fluctuations in the dynamic weights of the NXA strategy would render the strategy too costly to implement relative to the RW strategy. We address this concern by computing the break-even transaction cost τ^{be} as the proportional transaction cost that cancels out the positive performance fee of the NXA strategy relative to the RW strategy. An investor who pays a transaction cost lower than τ^{be} will continue to prefer a strategy that delivers a positive performance fee. Table 3 reveals that τ^{be} is generally high. At the target portfolio volatility of $\sigma_p^* = 10\%$, τ^{be} is 210 quarterly *bps* for the in-sample analysis, and 80 quarterly *bps* for the out-of-sample analysis. This means that the US investor would not switch from the RW strategy to the NXA strategy if he is subject to proportional transaction costs larger than 210 (80) quarterly *bps* for the in-sample (out-of-sample) analysis. In light of the fact that transaction costs in the FX market are very low and that our exercise allows portfolio rebalancing only once per quarter, it is highly unlikely that transaction costs can offset the positive performance fees from using the NXA strategy.[12]

Figure 4 offers a visual description of the time variation in the optimal portfolio weights for both the benchmark RW strategy and the NXA strategy. As expected, the weights are very smooth over time for the RW strategy, and remain reasonably smooth for the NXA strategy, suggesting that transaction costs should not play a major role.

Overall, both the in-sample and out-of-sample results suggest that the bilateral measures of US external imbalances contain economically valuable information for investors interested in forecasting nominal exchange rates.

5.2 Further Results and Robustness

This section discusses extensions and robustness of the core results on economic value described above.

5.2.1 Small Sample Bias

We are aware that small sample bias in the estimation of the parameters of the predictive regression (6) might arise. This estimation error would affect the portfolio weights, leading to suboptimal asset allocation. To account for this issue, we repeat the in-sample and out-of-sample economic value exercise when the predictive regression parameters are adjusted for small-sample bias. We proceed by generating 10,000 time series by means of moving blocks bootstrap (e.g. Gonçalves and White, 2005). Appendix B reports a description of the procedure. Table 4 presents the economic criteria for three target annualized portfolio volatilities, $\sigma_p^* = \{8\%, 10\%, 12\%\}$, and a degree of relative risk aversion $\delta = 6$. Again, the estimates of Φ and Θ are reported in annualized *bps*, whereas the estimates of τ^{be} are in quarterly *bps*. These results suggest that, while there is no change in the performance of the *RW* strategy, there is some enhancement of the performance of the *NXA* strategy. This is what one would expect since the estimation error surrounding the estimates in the predictive regression (6) for the *NXA* strategy plays some role for the predictive power of the information content in $nxa_t^{(i)}$, whereas the *RW* strategy is based on a driftless random walk model. For similar reasons, the gain is stronger in the out-of-sample exercise than in the in-sample analysis. This is understandable since the in-sample analysis is based on the estimation of parameters using the full data set, whereas the out-of-sample analysis is based on rolling regressions with a window of 20 years, hence with a smaller number of observations and larger estimation error. For example, comparing the results to the core findings given in Table 3 for $\sigma_p^* = 10\%$, the performance fee increases from 143 to 155 for the in-sample analysis, and from 230 to 250 for the out-of-sample analysis.

5.2.2 Global versus Bilateral *nxa*

We examine the predictive power of global *nxa* to assess whether it can replicate or improve the predictive power detected in bilateral *nxa*, in which case it would be unnecessary to work with our proxies for bilateral external imbalances. In this context the key reference is Alquist and Chinn (2008), who test the power of US global *nxa* to forecast three US bilateral exchange rates, showing good in-sample results but poor out-of-sample performance. In Table 5 we repeat the same asset allocation exercise as in Table 3 with the only difference that we use US global *nxa* rather than bilateral *nxa* to predict each of the four bilateral exchange rate returns. The results in Table 5 confirm that US global nxa has good in-sample predictive power in terms of economic metrics of evaluation, comparable to the economic value recorded for bilateral nxa in Table 3. However, global nxa performs poorly out-of-sample, being outperformed by the random walk benchmark. These results effectively confirm the evidence in Alquist and Chinn (2008) using economic, rather than statistical, criteria. For the purposes of this paper, this exercise suggests that the information content in bilateral nxa is more powerful than global nxa in forecasting bilateral exchange rates out-of-sample.

5.2.3 Base Currency

The valuation channel modelled in GR is very much inspired by countries such as the US, where the external imbalances are characterized by a substantial mismatch in the currency of denomination of assets and liabilities. This means that, while the theory and the valuation channel may be powerful empirically when forecasting the US dollar, they may be less powerful when considering exchange rates with respect to a different base (or domestic) currency. To address this issue we use the same predictive regressions and the same asset allocation exercise as in the core results, with the crucial difference that the US dollar is excluded from the investor's opportunity set. In other words, the investor can only trade four bonds (rather than five), denominated in Canadian dollar, Deutsche mark/euro, British pound and Japanese yen. In addition to excluding the US dollar from the portfolio, we also allow each of the other currencies left in the portfolio to be the base currency. In brief, this exercise enables us to assess the extent to which the core results are driven by the presence of the US dollar in the opportunity set of the investor and to the base currency considered. The results in Table 6 show that the economic value of bilateral nxa remains high and superior to the random walk benchmark, for each base currency considered. This leads us to conclude that the information content of nxa

for forecasting exchange rates is not specific to the US dollar.[13]

5.2.4 Trade versus Valuation Channels

It is instructive to assess the relative importance of net exports (nx) and net foreign assets (na) in determining the predictive power of bilateral nxa. We carry out the following exercise to shed some light on this issue. We start from noting that bilateral nx is observable since data on bilateral exports and imports are available, whereas na is not available on a bilateral basis. Therefore, defining $nxa_t^{(i)} \approx na_t^{(i)} - nx_t^{(i)}$, where $na_t^{(i)}$ and $nx_t^{(i)}$ denote bilateral detrended net exports and net foreign assets respectively, we calculate $na_t^{(i)}$ as the sum of $nxa_t^{(i)}$ and $nx_t^{(i)}$. We then consider an investment strategy where the forecasts of exchange rate returns are obtained from predictive regressions that use either $na_t^{(i)}$ or $nx_t^{(i)}$ as the predictive variable, and compute the usual economic metrics of evaluation.[14]

The results are displayed in Table 7, alongside the core results for bilateral nxa which were given in Table 3, to ease the comparison. This exercise reveals that both investment strategies (based either on bilateral na or nx as predictive variables) yield positive performance fees and sizable break-even transaction costs in-sample, although the performance of the investment strategy based on bilateral na performs better than the strategy based on bilateral nx. However, the out-of-sample results suggest that the investment strategy based on bilateral nx fails to outperform the random walk benchmark (negative fees), whereas the strategy based on bilateral na continues to perform better than a random walk benchmark. The NXA strategy dominates both strategies (using either bilateral na or nx) by some margin. Taken together, these results suggest that the asset/liability component is likely to play a more important role than the export/imports component in driving the forecasting power of cyclical external imbalances for exchange rates. However, combining the two components into one strategy (the NXA strategy) clearly leads to superior performance.

5.2.5 Data in Real Time

We are aware that our data are not in real time, i.e. we cannot guarantee that the data used to construct $nxa_t^{(i)}$ were available in a timely fashion to an investor at time t to generate forecasts of exchange rate returns at time $t+1$ over the sample period. We address this issue by constructing a real-time data set for the raw variables that are needed to construct $nxa_t^{(i)}$. In particular, we construct four vintages for each year starting from 1993Q1 and running through the end of the sample at 2007Q4. A description of the real-time data set is given in Appendix A. In essence, we replicate, to the extent that this is possible, the conditioning information set available to the investor over the out-of-sample period, and follow the same steps of estimation, forecasting and asset allocation carried out earlier using revised data. The results are reported in Table 8 and suggest that, although the economic value decreases slightly when using real time data, the NXA strategy continues to outperform the RW strategy by a large margin.

5.2.6 Summing up

The core result that the model conditioning on measures of bilateral external imbalances provides substantial economic value relative to the random walk benchmark appears to be robust. It is further enhanced when accounting for small sample bias in the estimated parameters of the predictive regression, and is robust to the choice of the base currency and the use of real time data. The analysis also shows that it is not possible to replicate these results simply using global nxa as opposed to bilateral nxa, and that the asset/liability component is likely to be more important than the exports/imports component in driving our results.

6 Conclusions

This paper extends empirically the model proposed by Gourinchas and Rey (2007) to bilateral nominal exchange rates and tests its implications for exchange rate predictability. The evaluation of the model is carried out in terms of economic significance, in a setting where a US investor employs the model for the purpose of allocating capital across countries. We employ economic criteria as it is well known that statistical evidence of exchange rate predictability in itself does not guarantee that an investor can exploit this predictability. Our methodology for measuring economic value is based on a stylized mean-variance framework.

We use, as predictive variables, estimated bilateral measures of cyclical external imbalances that are able to capture the trading and financial relations between the US and other major countries. Using criteria of economic significance, we find that the bilateral measure of US external imbalances delivers substantial economic gains to an international investor both in-sample and out-of-sample. These results provide sound evidence against the random walk benchmark, and are robust to the impact of transaction costs and real-time considerations. This is a promising result in the context of the empirical literature on exchange rate models based on fundamentals, which generally finds a feeble link between exchange rates and economic variables, especially at short horizons.

Overall, the results suggest that nominal exchange rates are determined and predictable by measures of bilateral external imbalances. This seems consistent with the simple intuition that if a country runs a persistent, negative cyclical external imbalance its currency will depreciate as an integral part of the process of international financial adjustment.

A Appendix: Real-Time Dataset

The real-time data are assembled and compiled from historical electronic and paper sources. The sample comprises quarterly observations on exports, imports, foreign assets, foreign liabilities, and wealth for the US, Canada, Germany, the UK and Japan. Each time series consists of revised data from 1973Q1 to 1992Q4 as known at 1993Q1, and real-time vintages ranging from 1993Q1 to 2007Q4. Starting from 1993Q1, we construct four vintages per year for a total of 60 real-time vintages until 2007Q4. When data are only available at annual frequency, we construct quarterly data by linear interpolation. Also, note that real-time data are at best obtained with a lag with respect to a given vintage. When data are available with more than one lag, we extract data by linear extrapolation. For example in 1993Q1, data on US exports are available until 1992Q4 while the same data for Canada are only available until 1992Q3. We construct the data point for 1992Q4 for Canada by linear extrapolation. Note that as real-time data, we mean t-dated data that were known to investors at time t. Similarly, real-time forecasts are t-dated forecasts that are exclusively based on information available to investors at time t. For instance, the first predictive regression is estimated in 1993Q1 using macroeconomic data from 1973Q1 to 1992Q4, and the first real-time forecast refers to the exchange rate return between 1993Q1 and 1993Q2. A breakdown of the sources is reported below.

US. Both revised and real-time seasonally adjusted quarterly data on exports and imports of goods and services are taken from the *BEA Survey of Current Business.* Revised annual data on foreign assets and liabilities are from Lane and Milesi-Ferretti (2007), while real-time annual data for the vintages 1993-1996 and 1997-2007 are collected from the International Monetary Fund's *Balance of Payments Statistics* (BOPS) and *International Financial Statistics* (IFS), respectively. Wealth is compiled as follows. We obtain revised annual data on household financial wealth for the period 1972-1975 from Goldsmith (1982). From the *Flow of Funds Account of United*

States, we collect revised seasonally adjusted quarterly data on the net financial investment of household, personal trust and non-profit organizations from 1976Q1 to 1992Q2, and real-time quarterly vintages on households and non-profit organizations financial wealth from 1993Q1 to 2007Q4.

Canada. Both revised and real-time seasonally adjusted quarterly data on exports and imports of goods and services are taken from *OECD Quarterly National Accounts* (QNA). Data on foreign assets and liabilities are collected from a variety of sources: revised annual data are from Lane and Milesi-Ferretti (2007); real-time annual vintages for the periods 1993-1996 and 1997-2003 are collected from the *BOPS* and the *IFS*, respectively; real-time quarterly vintages from 2004Q2 to 2007Q4 are taken from *Canada International Investment Position.* Wealth is proxied by the financial wealth of persons and unincorporated business. We collect revised annual data, real-time annual vintages from 1993 to 2002 and real-time quarterly vintages from 2003Q2 to 2007Q4 from *National Balance Sheet Account Canada.*

Germany. Both revised and real-time seasonally adjusted quarterly data on exports and imports of goods and services are taken from *QNA*. Revised annual data on foreign assets and liabilities are from Lane and Milesi-Ferretti (2007), while real-time annual vintages for the periods 1993-1996 and 1997-2007 are collected from *BOPS* and *IFS*, respectively. Wealth is proxied by household financial wealth. Revised annual data are obtained from the *Bundesbank Statistics Division*, while real-time annual vintages are from the *Bundesbank Monthly Report.*

UK. Both revised and real-time seasonally adjusted quarterly data on exports and imports of goods and services are taken from *QNA*. Revised annual data on foreign assets and liabilities are from Lane and Milesi-Ferretti (2007), while real-time annual data for the periods 1993-1996 and 1997-2007 are collected from *BOPS* and *IFS*, respectively. Wealth is proxied by households and non-profit institutions serving households financial wealth. We collect annual/quarterly revised data and real-time quarterly vintages from the *UK National Statistics.*

Japan. Both revised and real-time seasonally adjusted quarterly data on exports and imports of goods and services are taken from *QNA*. Revised annual data on foreign assets and liabilities are from Lane and Milesi-Ferretti (2007), while real-time annual data for the periods 1993-1996 and 1997-2007 are collected from *BOPS* and *IFS*, respectively. Wealth is proxied by households and non-profit institutions net worth. The *Japan Statistical Association* provides revised annual data from 1973 to 1984. From the *Japan Statistical Yearbook* we collect revised annual data and real-time annual vintages for the periods 1985-1992 and 1993-2007, respectively.

B Appendix: Small Sample Bias Correction

The small number of observations might cause bias in the parameter estimates. To take into account this effect, we consider the moving blocks bootstrap (e.g. Hall, Horowitz and Jing, 1995; Politis and White, 2004; Gonçalves and White, 2005). Let y_t be the dependent variable and x_{t-1} the predictive variable. We obtain bias-corrected parameter estimates as follows:

1. Run the predictive regression $y_t = \alpha + \beta x_{t-1} + \varepsilon_t$ and estimate $\widehat{\alpha}$ and $\widehat{\beta}$ by least squares.

2. Form an artificial sample $S_t^* = \left(y_t^*, x_{t-1}^*\right)$ by randomly sampling, with replacement, b overlapping blocks of length l from the sample $S_t = (y_t, x_{t-1})$.

3. Run the predictive regression $y_t^* = \alpha^* + \beta^* x_{t-1}^* + \varepsilon_t^*$ by least squares and obtain the estimates $\widehat{\alpha}^*$ and $\widehat{\beta}^*$.

4. Repeat $10,000$ times steps 2 and 3, and compute the bias-corrected estimates as difference between twice the estimates of α and β and the average estimates of α^* and β^*, respectively.[15]

Table 1. Descriptive Statistics

The table presents descriptive statistics for Canada, Germany, Japan, the UK and the US. a_t indicates the log foreign assets, l_t the log foreign liabilities, x_t the log domestic exports, and m_t the log domestic imports. nxa_t is the global measure of cyclical imbalances which linearly combines stationary components in foreign assets, liabilities, exports and imports as in Gourinchas and Rey (2007). $nxa_t^{(i)}$ is the bilateral measure of cyclical imbalances between the US and foreign country i. $s_t^{(i)}$ is the log of the nominal exchange rate between the US and foreign country i. Δ denotes first differences ($\Delta z_t = z_t - z_{t-1}$). The means and standard deviations are reported in percent units. ρ_l is the autocorrelation coefficient for a lag of l quarters. The data set covers quarterly data from 1973Q1 to 2007Q4.

	Δa_t	Δl_t	Δx_t	Δm_t	nxa_t	$nxa_t^{(i)}$	$\Delta s_t^{(i)}$
				Canada			
Mean	2.762	2.208	2.150	2.119	0.000	0.000	0.008
Sdev	1.509	1.257	6.733	6.184	5.789	11.780	2.667
ρ_1	0.828	0.863	−0.539	−0.272	0.827	0.718	0.117
ρ_2	0.659	0.730	0.469	0.081	0.751	0.639	−0.055
ρ_4	0.336	0.477	0.699	0.670	0.612	0.555	0.147
ρ_8	0.210	0.463	0.661	0.628	0.395	0.379	−0.074
				Germany			
Mean	2.733	2.809	1.862	1.824	0.000	0.000	0.546
Sdev	1.281	1.482	6.591	5.961	9.505	8.582	6.010
ρ_1	0.801	0.803	−0.501	−0.218	0.946	0.967	0.035
ρ_2	0.609	0.614	0.277	−0.132	0.918	0.937	−0.143
ρ_4	0.239	0.255	0.354	0.111	0.829	0.862	0.139
ρ_8	−0.083	0.049	0.354	0.157	0.584	0.703	0.049

(continued)

Table 1. Descriptive Statistics *(continued)*

	Δa_t	Δl_t	Δx_t	Δm_t	nxa_t	$nxa_t^{(i)}$	$\Delta s_t^{(i)}$
				Japan			
Mean	2.642	2.646	1.799	1.754	0.000	0.000	0.609
Sdev	3.611	4.021	7.423	7.306	10.080	8.480	5.867
ρ_1	0.745	0.792	−0.111	0.223	0.884	0.927	0.105
ρ_2	0.507	0.595	0.067	0.159	0.772	0.835	−0.110
ρ_4	0.049	0.222	0.450	0.112	0.533	0.656	0.121
ρ_8	−0.042	0.163	0.323	−0.040	0.017	0.220	−0.020
				UK			
Mean	3.419	3.515	2.348	2.351	0.000	−0.001	−0.153
Sdev	2.449	2.175	5.736	5.726	28.040	6.146	4.982
ρ_1	0.737	0.748	−0.262	−0.023	0.978	0.738	0.144
ρ_2	0.479	0.500	0.018	−0.245	0.939	0.645	−0.123
ρ_4	−0.025	0.013	0.266	0.247	0.839	0.562	0.074
ρ_8	0.113	0.119	0.315	0.340	0.652	0.301	−0.002
				US			
Mean	3.174	3.437	2.252	2.460	0.000		
Sdev	2.267	1.487	4.451	4.931	17.910		
ρ_1	0.793	0.825	−0.239	0.064	0.944		
ρ_2	0.591	0.660	0.481	−0.194	0.862		
ρ_4	0.193	0.366	0.633	0.404	0.660		
ρ_8	0.015	0.223	0.494	0.465	0.311		

Table 2. Predictive Regressions

The table reports the estimates of the predictive regression $(s_{t+k}^{(i)} - s_t^{(i)})/k = \alpha + \beta nxa_t^{(i)} + \varepsilon_{t+k}$ where $s_t^{(i)}$ is the log of the nominal exchange rate between the US dollar (USD) and the Canadian dollar (CAD), Deutsche mark/euro (EUR), Japanese yen (JPY) and British pound (GBP), respectively. $nxa_t^{(i)}$ is the bilateral measure of cyclical imbalances between the US and Canada, Germany, the UK and Japan, respectively. *S-test* is the Sargan's test statistic for the null hypothesis that the instrument set is valid, and R^2 is the in-sample coefficient of determination. Bootstrapped standard errors are reported in parentheses and asymptotic p-values in brackets. The superscripts *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The standard errors and statistical significance of β are obtained by generating 10,000 time series using the moving blocks bootstrap (see Gonçalves and White, 2005). The sample period comprises quarterly observations from 1973Q1 to 2007Q4.

k	1	2	3	4	8	12	16
				CAD			
β	0.003	−0.012	−0.017*	−0.024**	−0.040***	−0.036***	−0.029***
	(0.019)	(0.016)	(0.013)	(0.012)	(0.009)	(0.008)	(0.007)
S-test	1.649	0.706	0.712	0.518	2.373	4.189	3.515
	[0.438]	[0.703]	[0.700]	[0.772]	[0.305]	[0.123]	[0.172]
R^2	0.01	0.01	0.01	0.04	0.17	0.19	0.15
				EUR			
β	−0.134**	−0.130***	−0.126***	−0.119***	−0.110***	−0.086***	−0.071***
	(0.050)	(0.042)	(0.038)	(0.034)	(0.026)	(0.021)	(0.018)
S-test	0.767	1.051	2.144	2.342	0.335	0.218	0.163
	[0.681]	[0.591]	[0.342]	[0.310]	[0.846]	[0.897]	[0.922]
R^2	0.04	0.08	0.13	0.14	0.19	0.18	0.18
				GBP			
β	−0.015	−0.011	−0.029	−0.030	−0.051*	−0.066***	−0.081***
	(0.079)	(0.068)	(0.060)	(0.054)	(0.039)	(0.032)	(0.028)
S-test	0.240	0.383	0.486	0.586	1.951	1.100	0.306
	[0.887]	[0.825]	[0.784]	[0.746]	[0.378]	[0.577]	[0.858]
R^2	0.01	0.01	0.01	0.01	0.02	0.06	0.14
				JPY			
β	−0.173***	−0.164***	−0.146***	−0.130***	−0.088***	−0.037*	−0.013
	(0.054)	(0.047)	(0.042)	(0.038)	(0.029)	(0.024)	(0.021)
S-test	3.340	1.272	0.574	0.447	0.161	0.040	1.789
	[0.188]	[0.529]	[0.750]	[0.800]	[0.923]	[0.980]	[0.409]
R^2	0.07	0.11	0.15	0.14	0.13	0.04	0.01

Table 3. The Economic Value of Bilateral nxa

The table displays the in-sample and out-of-sample economic performance of currency strategies investing in the Canadian dollar (CAD), Deutsche mark/euro (EUR), British pound (GBP) and Japanese yen (JPY) relative to the US dollar (USD). NXA is a dynamic investment strategy which exploits the predictive information in the bilateral measure of cyclical imbalances between the US and Canada, Germany, the UK and Japan to forecast nominal exchange rate returns, respectively. RW is an investment strategy which uses the driftless random walk model to forecast nominal exchange rate returns. Each strategy considers a US investor who dynamically rebalances his wealth every quarter between the domestic bond in US dollar and four foreign bonds in foreign currencies. The exchange rate forecasts are used to convert the foreign bond returns in US dollar. The strategy maximizes expected returns subject to a given target volatility $\sigma_p^* = \{8\%, 10\%, 12\%\}$. The annualized percent mean, percent volatility and Sharpe ratio of each portfolio are denoted by μ_p, σ_p, and SR_p, respectively. Φ denotes the maximum performance fee a risk-averse investor with quadratic utility and a degree of relative risk aversion equal to 6 is willing to pay for switching from RW to NXA strategy. Θ measures the excess premium return of NXA relative to RW strategy. τ^{be} is the break-even proportional transaction cost which cancels out the utility advantage of the NXA relative to RW strategy. Φ and Θ are expressed in annual basis points, and τ^{be} in quarterly basis points. The in-sample analysis covers quarterly data from 1973Q1 to 2007Q4. The out-of-sample analysis uses a rolling window of 20 years and runs from 1993Q1 to 2007Q4.

	RW			*NXA*			*NXA vs. RW*		
σ_p^*	μ_p	σ_p	SR_p	μ_p	σ_p	SR_p	Φ	Θ	τ^{be}
				In-Sample					
8%	13.1	8.7	0.69	14.1	8.5	0.82	110	104	202
10%	14.7	10.8	0.70	15.8	10.4	0.83	143	136	210
12%	16.2	12.9	0.70	17.6	12.5	0.84	179	170	218
				Out-of-Sample					
8%	11.5	9.3	0.77	12.3	8.0	1.00	160	143	61
10%	13.3	11.6	0.78	14.3	10.1	1.00	230	199	80
12%	15.1	14.0	0.78	16.3	12.1	1.00	313	264	99

Table 4. The Economic Value of Bilateral nxa and Small Sample Bias

The table displays the in-sample and out-of-sample performance measures of currency strategies investing in the Canadian dollar (CAD), Deutsche mark/euro (EUR), British pound (GBP) and Japanese yen (JPY) relative to the US dollar (USD) when the parameter estimates are bias-corrected. NXA is a dynamic investment strategy which exploits the predictive information in the bilateral measure of cyclical imbalances between the US and Canada, Germany, the UK and Japan to forecast nominal exchange rate returns, respectively. RW is an investment strategy which uses the driftless random walk model to forecast nominal exchange rate returns. Each strategy considers a US investor who dynamically rebalances his wealth every quarter between the domestic bond in US dollar and four foreign bonds in foreign currencies. The exchange rate forecasts are used to convert the foreign bond returns in US dollar. The strategy maximizes expected returns subject to a given target volatility $\sigma_p^* = \{8\%, 10\%, 12\%\}$. The annualized percent mean, percent volatility and Sharpe ratio of each portfolio are denoted by μ_p, σ_p, and SR_p, respectively. Φ denotes the maximum performance fee a risk-averse investor with quadratic utility and a degree of relative risk aversion equal to 6 is willing to pay for switching from RW to NXA strategy. Θ measures the excess premium return of NXA relative to RW strategy. τ^{be} is the break-even proportional transaction cost which cancels out the utility advantage of the NXA relative to RW strategy. Φ and Θ are expressed in annual basis points, and τ^{be} in quarterly basis points. The bias-corrected parameters are obtained by generating $10,000$ time series using the moving blocks bootstrap (see Gonçalves and White, 2005). The in-sample analysis covers quarterly data from 1973Q1 to 2007Q4. The out-of-sample analysis uses a rolling window of 20 years and runs from 1993Q1 to 2007Q4.

	RW			NXA			NXA vs. RW		
σ_p^*	μ_p	σ_p	SR_p	μ_p	σ_p	SR_p	Φ	Θ	τ^{be}
				In-Sample					
8%	13.1	8.7	0.69	14.2	8.5	0.83	120	114	221
10%	14.7	10.8	0.70	16.0	10.5	0.85	155	148	230
12%	16.2	12.9	0.70	17.7	12.5	0.85	194	184	239
				Out-of-Sample					
8%	11.5	9.3	0.77	12.4	8.0	1.02	175	158	65
10%	13.3	11.6	0.78	14.5	9.9	1.03	250	219	81
12%	15.1	14.0	0.78	16.4	11.8	1.03	339	290	97

Table 5. The Economic Value of Global nxa

The table displays the in-sample and out-of-sample performance measures of currency strategies investing in the Canadian dollar (CAD), Deutsche mark/euro (EUR), British pound (GBP) and Japanese yen (JPY) relative to the US dollar (USD). NXA is a dynamic investment strategy which exploits the predictive information in the global measure of US cyclical imbalances to forecast nominal exchange rate returns. RW is an investment strategy which uses the driftless random walk model to forecast nominal exchange rate returns. Each strategy considers a US investor who dynamically rebalances his wealth every quarter between the domestic bond in US dollar and four foreign bonds in foreign currencies. The exchange rate forecasts are used to convert the foreign bond returns in US dollar. The strategy maximizes expected returns subject to a given target volatility $\sigma_p^* = \{8\%, 10\%, 12\%\}$. The annualized percent mean, percent volatility and Sharpe ratio of each portfolio are denoted by μ_p, σ_p, and SR_p, respectively. Φ denotes the maximum performance fee a risk-averse investor with quadratic utility and a degree of relative risk aversion equal to 6 is willing to pay for switching from RW to NXA strategy. Θ measures the excess premium return of NXA relative to RW strategy. τ^{be} is the break-even proportional transaction cost which cancels out the utility advantage of the NXA relative to RW strategy. Φ and Θ are expressed in annual basis points. τ^{be} is only reported for positive performance measures and is expressed in quarterly basis points. The in-sample analysis covers quarterly data from 1973Q1 to 2007Q4. The out-of-sample analysis uses a rolling window of 20 years and runs from 1993Q1 to 2007Q4.

	RW			NXA			NXA *vs.* RW		
σ_p^*	μ_p	σ_p	SR_p	μ_p	σ_p	SR_p	Φ	Θ	τ^{be}
				In-Sample					
8%	13.1	8.7	0.69	14.5	9.2	0.81	110	126	171
10%	14.7	10.8	0.70	16.4	11.3	0.82	132	157	172
12%	16.2	12.9	0.70	18.2	13.4	0.83	150	181	176
				Out-of-Sample					
8%	11.5	9.3	0.77	9.1	9.1	0.53	−227	−224	–
10%	13.3	11.6	0.78	10.3	11.3	0.53	−278	−275	–
12%	15.1	14.0	0.78	11.5	13.6	0.53	−327	−323	–

Table 6. The Economic Value of Bilateral nxa with Different Base Currencies

The table displays the in-sample and out-of-sample performance measures of currency strategies investing in the Canadian dollar (CAD), Deutsche mark/euro (EUR), British pound (GBP) and Japanese yen (JPY) relative to a given base (or domestic) currency. NXA is a dynamic investment strategy which exploits the predictive information in the bilateral measure of cyclical imbalances between the base country and the foreign country to forecast nominal exchange rate returns. RW is an investment strategy which uses the driftless random walk model to forecast nominal exchange rate returns. Each strategy considers an investor who dynamically rebalances his wealth every quarter between the domestic bond and three foreign bonds in foreign currencies. The exchange rate forecasts are used to convert the foreign bond returns in domestic returns. The strategy maximizes expected returns subject to a given target volatility $\sigma_p^* = 10\%$. The annualized percent mean, percent volatility and Sharpe ratio of each portfolio are denoted by μ_p, σ_p, and SR_p, respectively. Φ denotes the maximum performance fee a risk-averse investor with quadratic utility and a degree of relative risk aversion equal to 6 is willing to pay for switching from RW to NXA strategy. Θ measures the excess premium return of NXA relative to RW strategy. τ^{be} is the break-even proportional transaction cost which cancels out the utility advantage of the NXA relative to RW strategy. Φ and Θ are expressed in annual basis points, and τ^{be} in quarterly basis points. The in-sample analysis covers quarterly data from 1973Q1 to 2007Q4. The out-of-sample analysis uses a rolling window of 20 years and runs from 1993Q1 to 2007Q4.

	RW			NXA			NXA *vs.* RW		
Base	μ_p	σ_p	SR_p	μ_p	σ_p	SR_p	Φ	Θ	τ^{be}
				In-Sample					
CAD	13.4	10.5	0.55	14.7	10.2	0.70	152	151	167
EUR	11.3	10.3	0.56	12.6	10.0	0.71	152	152	228
GBP	15.2	10.5	0.55	16.5	10.2	0.70	159	151	208
JPY	10.0	10.3	0.56	11.3	10.1	0.70	150	153	233
				Out-of-Sample					
CAD	10.8	9.9	0.66	12.4	8.2	0.98	262	254	61
EUR	10.2	9.7	0.67	11.8	8.1	1.00	258	254	82
GBP	12.0	9.8	0.66	13.6	8.1	1.00	267	253	71
JPY	7.15	9.7	0.67	8.7	8.1	1.00	257	249	67

Table 7. The Economic Value of Bilateral na and nx

The table displays the in-sample and out-of-sample performance measures of currency strategies investing in the Canadian dollar (CAD), Deutsche mark/euro (EUR), British pound (GBP) and Japanese yen (JPY) relative to the US dollar (USD). NXA is a dynamic investment strategy which exploits the predictive information in the bilateral measure of cyclical imbalances between the US and Canada, Germany, the UK and Japan to forecast nominal exchange rate returns, respectively. NA is a dynamic investment strategy which exploits the predictive information in the bilateral measure of detrended net foreign assets to forecast nominal exchange rate returns. NX is a dynamic investment strategy which exploits the predictive information in the bilateral measure of detrended net exports to forecast nominal exchange rate returns. RW is an investment strategy which uses the driftless random walk model to forecast nominal exchange rate returns. Each strategy considers a US investor who dynamically rebalances his wealth every quarter between the domestic bond in US dollar and four foreign bonds in foreign currencies. The exchange rate forecasts are used to convert the foreign bond returns in US dollar. The strategy maximizes expected returns subject to a given target volatility $\sigma_p^* = \{8\%, 10\%, 12\%\}$. Φ denotes the maximum performance fee a risk-averse investor with quadratic utility and a degree of relative risk aversion equal to 6 is willing to pay for switching from RW to NXA (NA or NX) strategy. Θ measures the excess premium return of NXA (NA or NX) relative to RW strategy. τ^{be} is the break-even proportional transaction cost which cancels out the utility advantage of the NXA (NA or NX) relative to RW strategy. Φ and Θ are expressed in annual basis points. τ^{be} is only reported for positive performance measures and is expressed in quarterly basis points. The in-sample analysis covers quarterly data from 1973Q1 to 2007Q4. The out-of-sample analysis uses a rolling window of 20 years and runs from 1993Q1 to 2007Q4.

	NXA			NA			NX		
	Φ	Θ	τ^{be}	Φ	Θ	τ^{be}	Φ	Θ	τ^{be}
					In-Sample				
8%	110	104	218	65	57	44	42	38	41
10%	143	136	210	81	67	45	49	46	40
12%	179	170	218	97	79	46	54	54	38
					Out-of-Sample				
8%	160	143	57	103	73	108	−69	−73	–
10%	230	199	79	178	123	138	−90	−99	–
12%	314	264	102	275	183	167	−110	−130	–

Table 8. The Economic Value of Bilateral nxa in Real Time

The table displays the out-of-sample performance of currency investment strategies executed using real time data. The strategies invest in the Canadian dollar (CAD), Deutsche mark/euro (EUR), British pound (GBP) and Japanese yen (JPY) relative to the US dollar (USD) using real time forecasts. As real time data, we mean t-dated data that were known to investors at time t. Similarly, real time forecasts are t-dated forecasts which are based on information available to investors at time t. NXA is a dynamic investment strategy which exploits the real-time predictive information in the bilateral measure of cyclical imbalances between the US and Canada, Germany, the UK and Japan to forecast nominal exchange rate returns, respectively. RW is an investment strategy which uses the driftless random walk model to forecast nominal exchange rate returns. Each strategy considers a US investor who dynamically rebalances his wealth every quarter between the domestic bond in US dollar and four foreign bonds in foreign currencies. The exchange rate forecasts are used to convert the foreign bond returns in US dollar. The strategy maximizes expected returns subject to a given target volatility $\sigma_p^* = \{8\%, 10\%, 12\%\}$. The annualized percent mean, percent volatility and Sharpe ratio of each portfolio are denoted by μ_p, σ_p, and SR_p, respectively. Φ denotes the maximum performance fee a risk-averse investor with quadratic utility and a degree of relative risk aversion equal to 6 is willing to pay for switching from RW to NXA strategy. Θ measures the excess premium return of NXA relative to RW strategy. τ^{be} is the break-even proportional transaction cost which cancels out the utility advantage of the NXA relative to RW strategy. Φ and Θ are expressed in annual basis points, and τ^{be} in quarterly basis points. The out-of-sample analysis uses a rolling window of 20 years and runs from 1993Q1 to 2007Q4. Appendix A presents a description of the real-time dataset.

	RW			NXA			NXA *vs.* RW		
σ_p^*	μ_p	σ_p	SR_p	μ_p	σ_p	SR_p	Φ	Θ	τ^{be}
				Out-of-Sample					
8%	11.5	9.3	0.77	12.0	7.9	0.97	138	122	104
10%	13.3	11.7	0.77	13.9	9.9	0.98	206	174	123
12%	15.1	14.0	0.77	15.9	11.8	0.98	289	236	143

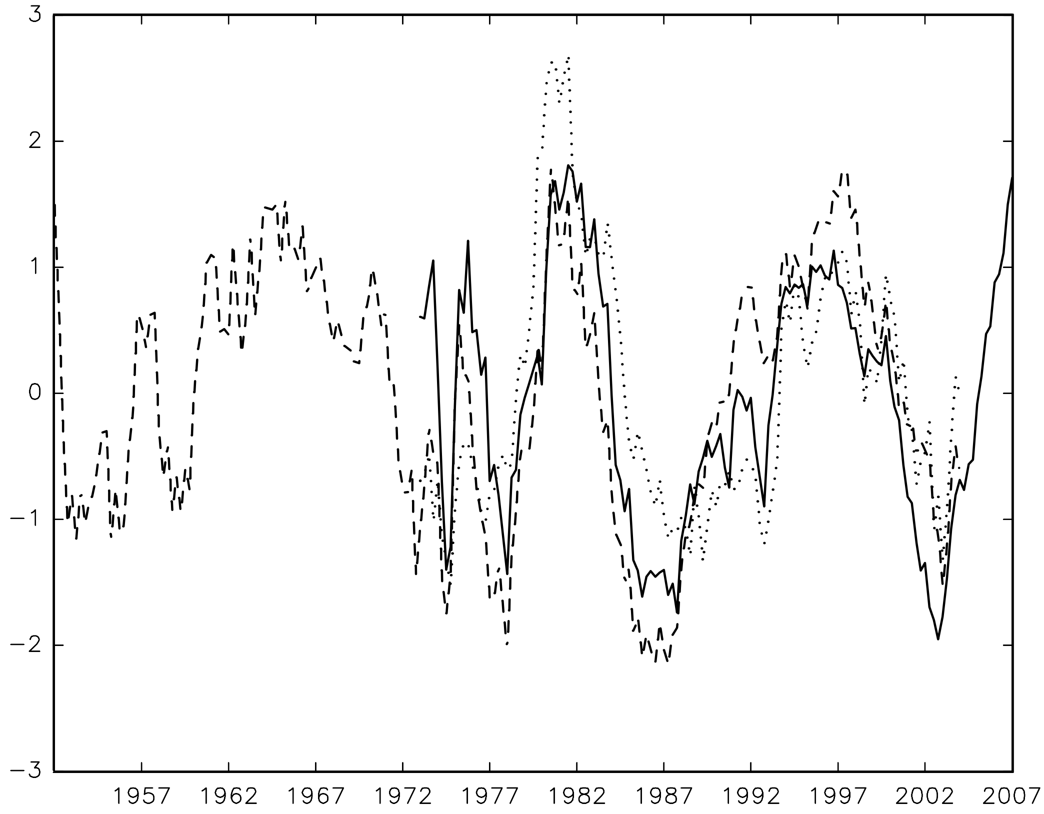

Figure 1. US Global Cyclical Imbalances

The figure displays the global measure of US cyclical imbalances nxa_t using different data sets. The dashed line denotes nxa_t from Gourinchas and Rey (2007) based on quarterly data ranging from 1952Q1 to 2004Q1. The dotted line denotes nxa_t from Gourinchas and Rey (2007) based on quarterly data from 1973Q1 to 2004Q1. The solid line denotes nxa_t constructed in this paper using quarterly data from 1973Q1 to 2007Q4. The time series are normalized to have zero means and unit standard deviations.

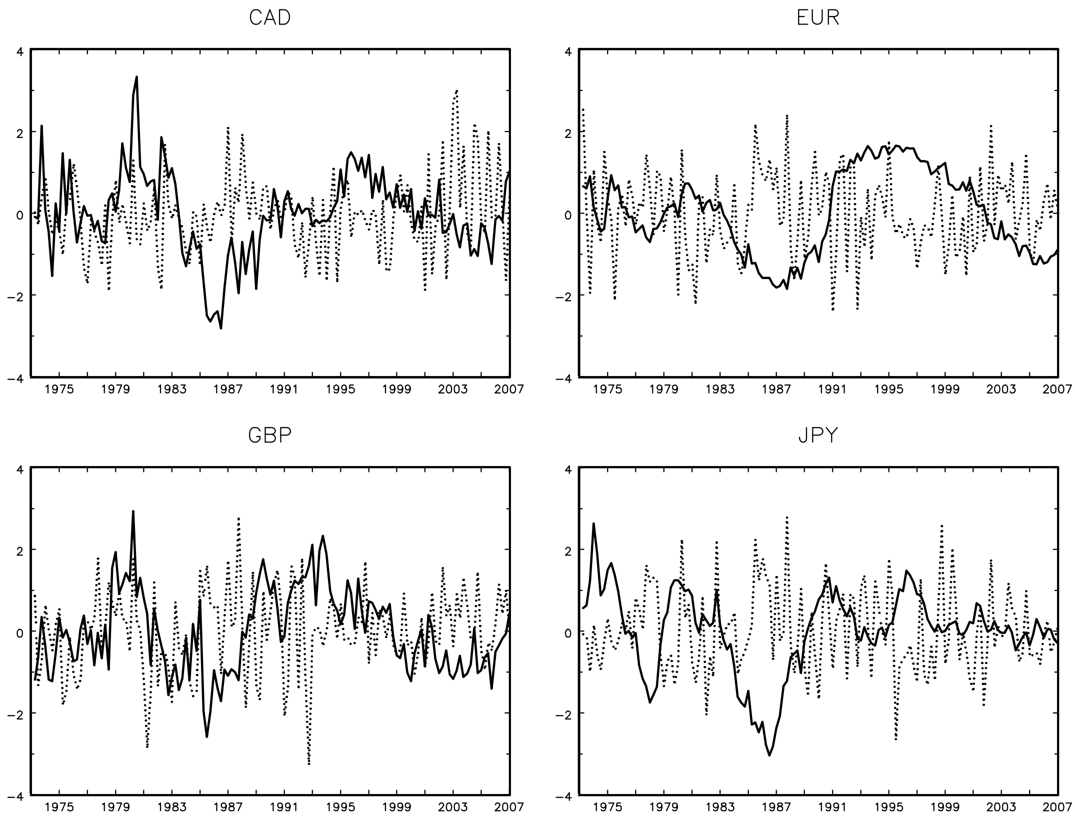

Figure 2. Bilateral Cyclical Imbalances and Quarterly Exchange Rate Returns

The figure displays $s_{t+1}^{(i)} - s_t^{(i)}$ (dotted line) and $nxa_t^{(i)}$ (solid line). $s_t^{(i)}$ denotes the log of the nominal exchange rate between the US dollar (USD) and the Canadian dollar (CAD), Deutsche mark/euro (EUR), British pound (GBP) and Japanese yen (JPY), respectively. The exchange rate is defined as units of USD per unit of foreign currency i. $nxa_t^{(i)}$ is bilateral measure of cyclical imbalance between the US and Canada, Germany, the UK and Japan, respectively. The data set comprises quarterly data ranging from 1973Q1 to 2007Q4. The time series are normalized to have zero means and unit standard deviations.

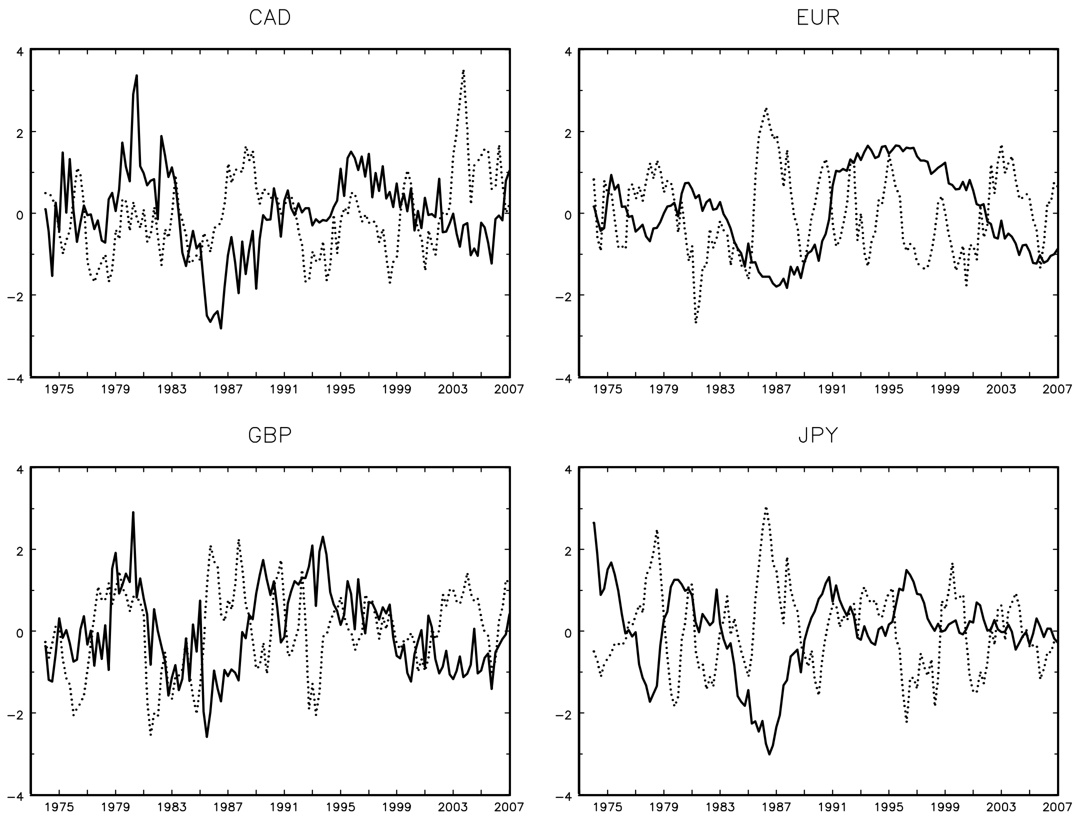

Figure 3. Bilateral Cyclical Imbalances and Annual Exchange Rate Returns

The figure displays $s_{t+4}^{(i)} - s_t^{(i)}$ (dotted line) and $nxa_t^{(i)}$ (solid line). $s_t^{(i)}$ denotes the log of the nominal exchange rate between the US dollar (USD) and the Canadian dollar (CAD), Deutsche mark/euro (EUR), British pound (GBP) and Japanese yen (JPY), respectively. The exchange rate is defined as units of USD per unit of foreign currency i. $nxa_t^{(i)}$ is bilateral measure of cyclical imbalance between the US and Canada, Germany, the UK and Japan, respectively. The data set comprises quarterly data ranging from 1973Q1 to 2007Q4. The time series are normalized to have zero means and unit standard deviations.

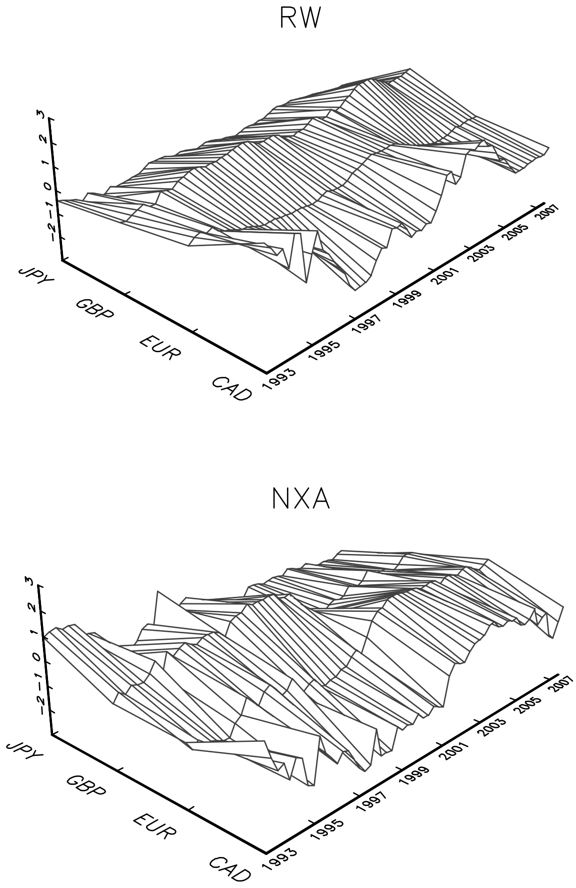

Figure 4. Out-of-Sample Portfolio Weights

The figure displays time variation in the out-of-sample optimal portfolio weights for selected currency strategies investing in the Canadian dollar (CAD), Deutsche mark/euro (EUR), British pound (GBP) and Japanese yen (JPY) relative to the US dollar (USD) when the target volatility is equal to 10%. RW is an investment strategy which uses the driftless random walk model to forecast nominal exchange rate returns. NXA is a dynamic investment strategy which exploits the predictive information in the bilateral measure of cyclical imbalances between the US and Canada, Germany, the UK and Japan to forecast nominal exchange rate returns, respectively. The out-of-sample analysis uses a rolling window of 20 years and runs from 1993Q1 to 2007Q4.

Notes

[1]The thinking of the model builds on earlier work on stock returns predictability by Campbell and Shiller (1998) and Lettau and Ludvigson (2001), carefully steered toward an international setting.

[2]However, it is important to note that the GR analysis is valid at the aggregate level for the effective exchange rate since it starts from a country's intertemporal budget constraint. As there is no bilateral budget constraint, the adaptation of the GR analysis to a bilateral context raises conceptual issues, which we discuss in the next section.

[3]Alquist and Chinn (2008) also emphasize the need to move to bilateral exchange rates and test the ability of nxa to forecast three US bilateral exchange rates. They find good in-sample results but poor out-of-sample evidence. However, Alquist and Chinn (2008) do not use bilateral measures of external imbalances, essentially employing the same predictive variable (the US global external imbalances) to forecast various bilateral exchange rates. Moreover, a key difference in our research is the emphasis on economic evaluation of the predictive information in nxa, as a complement to statistical tests.

[4]This is especially true for the US since almost all foreign liabilities are denominated in US dollars, whereas a large fraction of the foreign assets are in foreign currency. A US dollar depreciation, then, would transfer net wealth from the rest of the world to the US.

[5]In turn, the assumption of a balanced-growth path implies that (i) the rate of growth of external assets cannot permanently exceed the rate of growth of the economy, and (ii) the long-term growth rate of the economy is lower than the steady state rate of return. If these assumptions hold, then the steady-state average ratio of net exports to net foreign assets satisfies $NX/NA = \rho - 1 < 0$. This means that countries with long-run creditor positions ($NA > 0$) should run trade deficits ($NX < 0$), and countries with long-run debtor positions ($NA < 0$) should run

trade surpluses ($NX > 0$).

[6]The term 'global' is interchangeably used with 'multilateral' or 'aggregate' in this paper.

[7]Nevertheless, as pointed out to us by Professor Hélène Rey in private correspondence, there are plenty of examples in economic history showing that specific imbalances *vis-à-vis* some countries tend to be specifically addressed by policy makers, as witnessed by the recent pressure of the US on China to appreciate the renminbi to specifically address the US-China imbalance. Similarly, when some bilateral imbalance builds up, it is seems plausible to think that market forces induce the bilateral exchange rate to move in a direction that reflects that imbalance. Hence, even if we do not have specific theories about this bilateral mechanism, empirically the notion that bilateral measures of external imbalances are associated with bilateral exchange rates seems plausible.

[8]From 1973 to 1985 we construct these data for Germany assuming the same shares of exports and imports versus the US as of December 1986.

[9]Following GR closely, we filter out the trend component in (log) exports, imports, foreign assets, and liabilities relative to domestic wealth using the Hodrick-Prescott filter. We then combine these stationary components with weights reflecting the (trend) share of exports and imports in the trade balance, and the (trend) share of foreign assets and liabilities in the net foreign assets, respectively. These time-varying weights are replaced with their sample averages to minimize the impact of measurement error. See Sections II and III in GR for further details. Finally, note that the Hodrick-Prescott filter and the constant weights are based on the full-sample information in the in-sample analysis. In the out-of-sample, however, we perform the Hodrick-Prescott filter and compute the weights only using information available at the time of the forecast. This is to avoid any look-ahead bias.

[10]A widely used test statistic of equal forecast accuracy is the Diebold-Mariano-West statistic,

which has an asymptotic standard normal distribution for non-nested models (Diebold and Mariano, 1995; West, 1996). Clark and West (2007) develop a statistic which has a standard normal asymptotic distribution when comparing forecasts from nested linear models. However, it is well known that in finite samples bootstrap methods deliver more accurate tests in this context (see Rogoff and Stavrakeva, 2008).

[11]Quadratic utility exhibits increasing RRA. This is not appealing since an investor with increasing RRA becomes more averse to a percentage loss in wealth when his wealth increases. However, to account for this issue, West, Edison and Cho (1993) set the investor's RRA equal to a constant δ such that expected utility becomes linearly homogeneous in wealth, and compute the average realized utility in closed form. This represents a consistent estimate of the expected utility generated by a given level of initial wealth. For applications using this setting, see Fleming, Kirby and Ostdiek (2001, 2003), Marquering and Verbeek (2004), Han (2006), and Della Corte, Sarno and Tsiakas (2009).

[12]Turnover in the portfolio weights is clearly higher in the out-of-sample exercise, judging from the fact that τ^{be} reduces from 210 to 80 when moving from in-sample to out-of-sample analysis. Although this is a large change, it is worth noting that even 80 *bps* constitutes a huge number in this context given that in recent years the spread on liquid exchange rates was never higher than 5-6 bps and that in the more distant past (or the least liquid periods) it would never have been larger than 20 *bps* for the major exchange rates examined in this paper (e.g. see Aliber, Chowdhry and Yan, 2003; Akram, Rime and Sarno, 2008).

[13]In fact, note that the performance fees are higher in these NXA portfolios relative to the core results in Table 3 even though they are based on a smaller set of assets. The reason is that the benchmark RW strategy performs much worse with the portfolios that exclude the US dollar, rather than a genuine improvement of the NXA strategy. This can be seen by noting the

reduction in Sharpe ratios for the RW strategy in Table 6 relative to Table 3. In other words, the higher performance fees of the NXA strategy in Table 6 reflect an improvement relative to the random walk model, not an absolute improvement in performance.

[14]Since na and nx can be correlated, there will not be an exact decomposition of the variance of nxa into the variance of na and the variance of nx. As a consequence, conditioning on both na and nx will not account for the covariance term that can play a role when considering nxa.

[15]Specifically, bias-corrected estimates are given by $\widehat{\alpha}_{BC} = \widehat{\alpha} - [E(\widehat{\alpha}^*) - \widehat{\alpha}] = 2\widehat{\alpha} - E(\widehat{\alpha}^*)$, and $\widehat{\beta}_{BC} = \widehat{\beta} - [E(\widehat{\beta}^*) - \widehat{\beta}] = 2\widehat{\beta} - E(\widehat{\beta}^*)$, respectively.

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