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 theoretically-motivated 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 criteria of economic profitability. The analysis shows that the model delivers tangible economic value to a risk averse investor, who will pay high performance fees to switch from a portfolio strategy based on the random walk benchmark to one that conditions on the structural model. The results are robust to the presence of reasonable transaction costs across various forecasting performance criteria, and they are further enhanced when sensible economic restrictions are imposed on the predictive model.

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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 3 trillions US dollar (Bank for International Settlements, 2007), a third of which is in spot transactions. 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 suggests 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).

The challenge to relate exchange rates to economic fundamentals has recently received an important development with the model of international financial adjustment by Gourinchas and Rey (2007), hereafter GR.[1] The model gives useful insights about 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 main implication of GR theory 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 for this prediction of the model using data for the effective US dollar 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 standard 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 five bonds, one domestic and four foreign bonds (for the UK, Germany, Japan and Canada). We compare the out-of-sample performance of a benchmark portfolio strategy based on the random walk benchmark relative to a portfolio strategy that exploits the 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

[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.

strategy to the strategy conditioning on *nxa*. In addition, we employ the performance measure recently proposed by Goetzmann, Ingersoll, Spiegel and Welch (2007), which does not assume a specific utility function. Also, we report evidence on the impact of transaction costs 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* implies that, while GR carry out their empirical work using statistical tests applied to the US effective exchange rate, our analysis requires moving to a set of bilateral exchange rates. This is important because bilateral 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. We use, as predictive variables, proxies for bilateral external imbalances between the US and other major countries (instead of using a single measure of US global external imbalances). Using a data set that comprises quarterly exchange rate returns ranging from January 1973 through December 2004 for four major US dollar exchange rates, the construction of the bilateral external imbalances is conceptually identical to GR but requires some amendments when one moves away from US effective data alone. We construct these measures using the data set compiled by Lane and Milesi-Ferretti (2007), which includes statistics on the foreign assets and liabilities of 145 countries at market value for the period 1970-2004.[2]

To anticipate our main results, the analysis provides robust evidence that bilateral external imbalances have strong predictive ability for exchange rate returns, as measured on the basis of several out-of-sample performance measures. We find large economic gains to an investor who allocates capital internationally simply using the predictions implied by *nxa*, conditional on available information at the time of the forecasts. Specifically, the evidence shows that the economic value of *nxa* is larger than the gain obtainable from trading on the basis of the random walk benchmark. This is especially true when the model conditioning on *nxa* allows for sensible economic restrictions, as opposed to using the forecasts of exchange rate returns even when they happen to be inconsistent with economic theory, following a similar logic to the analysis recently proposed by Campbell and Thompson (2008) for stock returns. We conclude that *nxa* captures information about future exchange rate movements during the recent floating period. Put another way, *nxa* would have helped a real-world investor benefit from fundamentals-based currency speculation, as one would expect from a state variable that summarizes the expectations of rational economic agents about future exchange rate returns. We view this result as very encouraging, given the evidence provided

[2] 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 do not use bilateral measures of external imbalances, essentially employing the same predictive variable (the US global external imbalances) to forecast 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.

by a vast body of literature on exchange rate forecasting that the state of the economy is not related in a meaningful fashion to quarterly 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 our approach for testing the implications of this model for bilateral exchange rate predictability. Section 3 describes the data, whereas Section 4 reports the estimation results for regressions that investigate the predictive power of *nxa* for exchange rate returns at various horizons. Section 5 outlines the framework for assessing the economic value of exchange rate predictability for a risk-averse investor with a dynamic portfolio allocation strategy. Section 6 reports the empirical results for the economic value analysis. Finally, Section 7 concludes. In the Appendix, we provide further details on the data construction as well as a description of the bootstrap methods used in the paper.

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.

2.1 Stylized Facts and Exchange Rate Predictability

Economic fundamentals can generally explain at most a small part of nominal exchange rate changes (Meese and Rogoff, 1983; Mark, 1995; Kilian, 1999; Berkowitz and Giorgianni, 2001; 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, 2007).

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, domestic currency depreciation contributes to the process of international adjustment through future trade surpluses. This link between a current deterioration in net savings and future trade surpluses 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 the net foreign portfolio returns causes a net wealth transfer, thus contributing to the external adjustment via the *valuation channel*.[3]

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

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

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.[4]

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, assets, and liabilities, 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 assets and exports and decreases with 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 $t+1$; it increases with cyclical export growth and decreases with cyclical

[3] 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.

[4] Exports and imports only include transactions in goods and services because income payments and unilateral transfers in the current account of the US and, to a lesser extent, other major economies are relatively small. All variables in equation (1) are defined as beginning-of-period variables.

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 a via high returns on its net foreign asset portfolio ($r_{t+1} > 0$).[5]

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:

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

which requires the no-Ponzi condition that nxa_t cannot grow faster than the steady state growth-adjusted interest rate.[6] 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:

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

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 ($E_t \Delta nx_{t+i} > 0$), but also an increase in future returns on net foreign assets ($E_t r_{t+i} > 0$). 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 nominal exchange rate return defined as 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

[5] For further details, see Appendix A.

[6] In turn, the assumption of a balanced-growth path implies that (i) the rate of growth of external assets cannot permanently exceeds 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 this assumption holds, 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 ($NX > 0$).

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 can predict a future currency appreciation, whereas a negative value can anticipate a future currency depreciation.

2.3 Extension to Bilateral Exchange Rates

In the empirical analysis of GR, nxa is constructed using aggregate exports, imports, foreign assets and liabilities, and is shown to contain significant out-of-sample forecasting power at all horizons between one and 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.[7]

However, a 'bilateral' measure of cyclical external imbalances is desirable since effective exchange rates are not tradable assets. Since disaggregated data are generally not available, a bilateral measure of cyclical global imbalances is not directly observable. One might be tempted to use global nxa as a proxy for the unobservable bilateral nxa. This practice may not be entirely appropriate for at least two reasons. First, the aggregate measure of cyclical external imbalances might not necessarily entail the negative relation between cyclical external imbalances and future exchange rate movements suggested by the theory.[8] Second, global nxa, if used as predictive variable in a regression for bilateral exchange rate returns, would cause an errors-in-variable problem, leading to inconsistent least squares estimates.

Ultimately, we aim at estimating the following predictive regression

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

where $\Delta_k s_{t+k}^{(i)} = s_{t+k}^{(i)} - s_t^{(i)}$ is the nominal exchange rate return between time t and $t+k$; $s_t^{(i)}$ is the log exchange rate at time t, defined as domestic price of the foreign currency i; $nxa_t^{(i)}$ is the bilateral measure of cyclical external imbalances between the domestic economy and the foreign country i at

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

[8] An important caveat is 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, or even permanent deficit, with another country, as long it runs a similar-size surplus with other economies. In this case, some of the bilateral external imbalances would effectively be non-stationary processes and be unrelated to future exchange rate movements, which would also raise problems of statistical inference in standard exchange rate predictive regressions. However, it seems reasonable to expect that these considerations are largely irrelevant when using long spans of data across major economies. Empirically, both the aggregate and bilateral measure of external imbalances are mean reverting and, hence, change sign over the sample, making these concerns irrelevant for our purposes (results available upon request).

time t. In our setting the US is the domestic economy. Since data on bilateral external assets and liabilities are not available, we can construct nxa_t (the global measure of cyclical external imbalances for the domestic country) 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. Under this procedure, the global measure nxa_t for the domestic economy is first regressed on a set of instruments. Then the fitted value from this regression is used as a proxy for $nxa_t^{(i)}$ in equation (6). Finally, the specification is estimated by least squares.

The IV method, however, requires a set of instruments that are correlated with the 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 measure of cyclical external imbalances for the foreign country i, which obviously must contain the same information between the domestic economy and the foreign country i as in the aggregate nxa_t for the domestic economy. As an additional instrument, we define the detrended net exports $nx_t^{(i)}$ between the domestic economy and the foreign economy i as a linear combination of the stationary components of (log) bilateral exports and imports.[9]

3 Empirical Results

3.1 Data and Descriptive Statistics

The data sample consists of quarterly observations ranging from March 1973 to December 2004, and comprises four spot exchange rates relative to the US dollar: the British pound (GBP), the euro (EUR), the Japanese yen (JPY), and the Canadian dollar (CAD). For EUR, we use the Deutsche mark until December 1998. The exchange rate is defined as the US dollar price of the foreign currency. We also use Eurocurrency deposit rates with three-month maturity, as a proxy for the riskless rate, in the asset allocation problem described in the next section. These data are obtained from *Datastream*. Data on aggregate exports, imports, external assets, external liabilities, and domestic wealth for the US, the UK, Germany, Japan and Canada are obtained from various sources, and a detailed description is given in Appendix A.1.

Table 1 reports the descriptive statistics for the quarterly percent changes in log external assets Δa_t, liabilities Δl_t, exports Δx_t, and imports Δm_t, the global measure of cyclical external imbalances nxa_t, and the nominal exchange rate returns $\Delta s_t^{(i)}$. The table also reports the US bilateral measure

[9] For example, suppose we want to forecast the nominal exchange rate between the US dollar and the British pound. First, we regress the US aggregate nxa_t on a constant term, the British aggregate 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 independent variable in the predictive 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. The regressions are both estimated by least squares.

of cyclical external imbalances $nxa_t^{(i)}$. Appendix A.2 provides a detailed description of how nxa_t is constructed. As one would expect, foreign assets and liabilities show lower volatility and higher serial correlation than exports and imports. For the sample period investigated, global nxa_t has a sample mean of zero, a large standard deviation and high serial correlation. Also, $nxa_t^{(i)}$ has similar properties to nxa_t. Consistent with stylized facts, bilateral exchange rate returns have very low serial correlation, sample means close to zero, and annualized standard deviations around 10%, except for the CAD that is less volatile.[10]

3.2 GR Replication

Before investigating the predictive ability of the bilateral measures of US external imbalances, it is important to notice that our source of aggregate exports, imports, external assets and liabilities for the US differs from GR. To ensure that our data set has comparable properties, we carry out a preliminary exercise by estimating the following predictive regression:

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

where $\Delta_k s_{t+k} = s_{t+k} - s_t$ is the US nominal effective exchange rate (NEER) return between time t and $t+k$; s_t is the log-effective exchange rate at time t; the horizon k ranges from 1 quarter to 16 quarters; and nxa_t is the US aggregate cyclical external position at time t.[11]

The in-sample results for specification (7) are reported in Table 2. The estimates of β display the expected negative sign and are statistically significant at all horizons, although the magnitude is slightly smaller than in GR.[12] The R^2 is increasing with k, peaking at $k = 8$ (2-year horizon) where it reaches 44%, before declining to 21% for $k = 16$ (4-year horizon).

We further assess the out-of-sample performance of nxa_t by testing 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.[13] The MSE-*adjusted* statistic is computed by defining

$$\widehat{f}_{t+k} = (\Delta_k s_{t+k})^2 - (\Delta_k s_{t+k} - \Delta_k \widehat{s}_{t+k})^2 + (\Delta_k \widehat{s}_{t+k})^2 \tag{8}$$

[10] Table 1 reports the quarterly standard deviation *Std Dev*. The annualized standard deviation is simply *Std Dev* $\times\sqrt{4}$.

[11] The US nominal effective exchange rate is obtained from the *International Financial Statistics* database of the International Monetary Fund.

[12] Notice that GR define the k-horizon exchange rate return between t and $t+k$ as $\Delta_k s_{t+k}/k$. Our empirical analysis employs $\Delta_k s_{t+k}$ but the estimated coefficients reported are divided by k to ease the comparison across forecast horizons and with the empirical results of GR.

[13] 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.

where $\Delta_k \widehat{s}_{t+k}$ is the forecast implied by the predictive regression (7). Then, the test for equal MSE is performed by regressing $\widehat{f}_{t+k}$ on a constant and calculating the resulting t-statistic for a zero coefficient. A p-value for a one-sided test could be obtained using the standard normal distribution. In our empirical analysis, $\widehat{f}_{t+k}$ is computed using forecasts $\Delta_k \widehat{s}_{t+k}$ based on a 20-year rolling window. Then, given the relatively small number of out-of-sample forecasts, we compute the one-sided p-value using a bootstrap procedure, detailed in Appendix B.1, rather than relying on asymptotic critical values.

Table 2 also reports the bootstrapped p-value for the MSE-*adjusted* statistic. These results confirm the out-of-sample forecast accuracy of nxa_t first documented by GR. In particular, the null hypothesis of equal predictive accuracy is rejected at the 1% significance level for all forecast horizons up to 3 years, suggesting that the model conditioning on nxa_t outperforms a driftless random walk in forecasting the out-of-sample NEER return. Overall, Table 2 replicates qualitatively the main results of GR both in-sample and out-of-sample, suggesting that our measure of global nxa_t has comparable properties to the measure used 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. The fitted value from this regression is, then, used as bilateral measure of cyclical external imbalances between the US and the foreign country in the predictive regression (6) to forecast the k-period nominal exchange rate return between the US dollar and the foreign currency.[14]

Table 3 displays the results from the two-stage regression (6), where $nxa_t^{(i)}$ is the bilateral measure of external imbalances for the US relative to the UK, Germany, Japan and Canada, respectively; and $\Delta_k s_{t+k}^{(i)}$ is the k-period nominal exchange return for the US dollar relative to the British pound, the Deutsche mark/euro, the Japanese yen, and the Canadian dollar, respectively.

The relation between $nxa_t^{(i)}$ and $\Delta_k s_{t+k}^{(i)}$ should be negative, since the theoretical model implies that negative values of bilateral cyclical external imbalances between the US and, for instance, the UK would forecast future depreciations of the US dollar with respect to the British pound. Indeed, Table 3 shows that for all four bilateral exchange rate returns the value of the estimated coefficients on $nxa_t^{(i)}$ is negative for all horizons k. We report the estimated coefficients divided by k to permit

[14] We test the null hypothesis of valid instruments (overidentifying restrictions) using the Sargan test. The results, not reported but available upon request, confirm the validity of the set of instruments.

an easier comparison of results across forecast horizons. The empirical evidence is particularly strong for EUR, where the coefficients are large in magnitude and strongly significantly different from zero. For JPY the predictive power of $nxa_t^{(i)}$ is statistically significant up to 2 years ahead, whereas for CAD statistical significance is only established for horizons of 2 years or longer. The weakest results are for GBP, where the coefficient on $nxa_t^{(i)}$ is only significant for horizons of 3-4 years. Moreover, while the impact of external imbalances on exchange rate predictability decreases at longer horizons for JPY, the evidence is reversed for CAD, EUR and GBP.

Figure 1 reports the exchange rate returns and the bilateral cyclical imbalances for all countries in our sample. The dotted lines represent quarterly exchange rate returns $\Delta s_{t+1}^{(i)}$, and the solid lines are the lagged measures of bilateral external imbalances $nxa_t^{(i)}$. Notice that the time series are both standardized to have zero mean and unit standard deviations. The graphs provide a clear visual illustration of the general co-movement between exchange rate returns and the lagged bilateral measures of external imbalances.

Overall, these results extend the validity of the GR model to bilateral exchange rates when measures of bilateral external imbalances are taken into account. We now turn to the analysis of the economic value of the predictive power of $nxa_t^{(i)}$.[15]

4 Economic Value: The Setting

Statistical evidence of predictability does not necessarily imply tangible economic gains (Leitch and Tanner, 1991; Elliott and Ito, 1999; Della Corte, Sarno and Thornton, 2008). Since criteria that account for investors' preferences are desirable to evaluate the predictive power of a model, we proceed with a description of the framework used to examine the economic significance of models that condition on bilateral measures of US 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 (UK, Germany, Japan and Canada). The domestic and foreign riskless assets are proxied by 3-month Eurocurrency deposits. The yield of the foreign bonds is riskless in local currency but risky when expressed in domestic currency. Indeed, 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

[15] We also performed out-of-sample forecasts by estimating the predictive equation (6) using 20-year rolling regressions and comparing its performance relative to a driftless random walk model using the Clark and West (2007) MSE-*adjusted* statistic of forecast accuracy. The results are largely consistent with the in-sample analysis presented in Table 3. Given the focus of this paper on the economic value of $nxa_t^{(i)}$, we do not report these results, but they remain available upon request.

$t+1$. This implies that at time t, the only risk the US investor is exposed to is FX risk.

To manage this 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 conditional means of exchange rate returns. Since we do not model the dynamics of the conditional covariance matrix of exchange rate returns, we use the unconditional covariance matrix at time t to forecast the covariance matrix for the next period. Second, conditional on 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 to what extent the model conditioning on the bilateral measures of US cyclical imbalances is economically superior to the naive random walk benchmark.

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 portfolio expected 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 feeding the maximum return strategy with 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:

$$\max_{w_t} \left\{ \mu_{p,t+1|t} = w_t'\mu_{t+1|t} + (1 - w_t'\iota) r_f \right\} \qquad (9)$$
$$s.t. \quad (\sigma_p^*)^2 = w_t'\Sigma_{t+1|t} w_t$$

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

$$w_t = \frac{\sigma_p^*}{\sqrt{C_t}} \Sigma_{t+1|t}^{-1} (\mu_{t+1|t} - \iota r_f) \qquad (10)$$

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

$$R_{p,t+1} = 1 + w_t' r_{t+1} + (1 - w_t' \iota) r_f = R_f + w_t' (R_t - \iota R_f) \tag{11}$$

where R_t is the $N \times 1$ vector of gross risky returns, and R_f is the gross domestic riskless rate. Recall that, since we do not model the 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 though of 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 would be willing to pay to have access to the additional information available in $nxa_t^{(i)}$, the measure of US bilateral imbalances, relative to the benchmark random walk model.

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:

$$\sum_{t=0}^{T-1} \left\{ (R_{p,t+1}^* - \Phi) - \frac{\delta}{2(1+\delta)} (R_{p,t+1}^* - \Phi)^2 \right\} = \sum_{t=0}^{T-1} \left\{ R_{p,t+1} - \frac{\delta}{2(1+\delta)} R_{p,t+1}^2 \right\} \tag{12}$$

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 fees in basis points.[16]

[16] Quadratic utility exhibits increasing RRA. This is counterintuitive since an investor with increasing RRA becomes more averse to a percentage loss in wealth when his wealth increases. 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).

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

$$M\left(R_p\right) = \frac{1}{(1-\delta)} \ln\left\{\frac{1}{T}\sum_{t=0}^{T-1}\left(\frac{R_{p,t+1}}{R_f}\right)^{1-\delta}\right\} \tag{13}$$

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:

$$\Theta = M(R_p^*) - M(R_p). \tag{14}$$

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

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 both the NXA and RW 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 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 basis points.

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 March 1973 to December 2004 to estimate the predictive regression (6). The out-of-sample analysis uses a 20-year rolling predictive regression, and runs from March 1993 through December 2004. 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.[17]

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 basis points (bps) whereas the estimates of τ^{be} are given in quarterly bps.

Table 4 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 185 annual *bps,* whereas the excess premium return the NXA strategy yields in excess to the RW strategy is 177 annual *bps*. These results are also reflected in the risk-return trade-off as measured by SR. The NXA strategy delivers an SR of 0.91, larger than 0.71, which is the SR of the RW strategy.

The out-of-sample results confirm that there is high economic value in 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). In this context, the out-of-sample results clearly indicate the additional economic gains that a US investor would have enjoyed by using the NXA strategy relative to the random walk benchmark model. These results are qualitatively identical to the in-sample ones. At the target

[17] One issue we abstract from is, however, the fact that economic data are subject to revisions and delays in the releases from statistical offices. Specifically, our data are not exactly real-time data since they would have undergone some revision to correct measurement errors. Nothing is known on the extent of measurement errors and delays in this context since–to the best of our knowledge–there is no study on real-time data of this kind. However, we carry out a robustness check below where we lag the information set available to the investor to assess the importance of lags in information arrival.

portfolio volatility of $\sigma_p^* = 10\%$, a US investor is willing to pay 200 annual *bps* for switching from the RW to the NXA strategy, which is comparable to the excess premium return of 192 annual *bps*. Similarly, the SR increases from 0.88 to 1.32 when the investor uses the NXA strategy rather than the RW strategy.

Finally, if transaction costs are sufficiently high, the quarterly 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 which 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. The values for τ^{be} are only reported for positive Φ. Table 4 reveals that τ^{be} is generally high. At the target portfolio volatility of $\sigma_p^* = 10\%$, τ^{be} is 137 quarterly *bps* for the in-sample analysis, and 164 quarterly *bps* for the out-of-sample analysis. This means that the US investor will never switch from the RW strategy to the NXA strategy if he is subject to proportional transaction costs larger than 137 (164) 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, it seems very unlikely that transaction costs can offset the positive performances fees from using the NXA strategy.

Overall, both the in-sample and out-of-sample 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 some extensions of the core results on economic value described above, followed by some robustness checks.

First, 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 block bootstrap. Appendix B.2 reports a detailed description of the procedure. Table 5 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 the improvement in the performance of the RW strategy is miniscule, the enhancement for the NXA strategy is more substantial. This is what one would expect since the NXA strategy requires the estimation of one extra parameter relative to the RW strategy. Hence, the mitigation of the estimation error surrounding the estimates in the predictive regression (6) plays a bigger role for the predictive power of the information content in $nxa_t^{(i)}$. For similar reasons, the gain is much 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 4 for $\sigma_p^* = 10\%$, the performance fee increases from 185 to 189 for the in-sample analysis, and from 200 to 275 for the out-of-sample analysis.

Second, we examine the impact of imposing meaningful economic restrictions on the forecasts of exchange rate returns in the spirit of Campbell and Thompson (2008). Specifically, we replicate the out-of-sample performance measures under three sets of restrictions. *Rest 1* indicates that the slope in the predictive regression (6) is set to zero when it is estimated with a positive sign. This restriction is justified by the negative relation suggested by the theoretical model of GR. *Rest 2* indicates that the forecast generated by the predictive regression (6) is set to zero when it is estimated with the opposite of the theoretically predicted sign. For instance, a positive value of $nxa_t^{(i)}$ at time t should generate a negative forecast of exchange rate returns for the period t to $t+1$, corresponding to a future appreciation of the US dollar against currency i. We set this forecast equal to zero when the return forecast turns out to have a positive sign. This may be caused either by the intercept or the sign of the slope or both. *Rest 1&2* refers to the case when both *Rest 1* and *Rest 2* are simultaneously imposed. The results from this analysis are reported in Table 6. They clearly lead to an improvement in the economic value of the NXA investment strategy relative to the RW strategy. Consider $\sigma_p^* = 10\%$ as target volatility. While *Rest 1* has a negligible impact, *Rest 2* leads to a marked improvement since the performance fee increases from 200 to 316 annual *bps*. *Rest 1&2* also implies a performance fee of 316 annual *bps*, largely due to the impact of *Rest 2*. The other performance measures confirm these findings, indicating that the performance of the NXA strategy is further enhanced when meaningful, theoretically-consistent restrictions are imposed in the predictive regressions.

Third, 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 $t+1$. We address the impact of this issue by lagging $nxa_t^{(i)}$ in the conditioning information set available to the investor. We thus report the out-of-sample economic criteria when the predictive variable is available with a different delay. Specifically, we consider the predictive regression $\Delta s_t^{(i)} = \alpha + \beta nxa_{t-Lag}^{(i)} + \varepsilon_t$, and investigate the case $Lag = 2$ (corresponding to a six-month time difference between the predictive variable and the return to forecast), and $Lag = 4$ (corresponding to a one-year time difference between the predictive variable and the return to forecast). Furthermore, we calculate the economic criteria when both delays in the available of information and economically meaningful restrictions are considered. We report these results in Table 7. Notice that NXA_{Lag1} is equivalent to the predictive regression used to obtain the core results presented in the previous tables on economic value, whereas *No Rest* corresponds to the case when no economic restrictions are imposed. Although the economic value tends to decrease when lagging the information set available, which is expected, the NXA strategy continues to outperform the *RW* strategy even with 2 lags in the information set. Conversely, the NXA strategy fails to beat the *RW* strategy when 4 lags in the information set are considered. With the economic restrictions, however, we note again the power of imposing *Rest 2* (and consequently *Rest 1&2*). Indeed, in this case we find a large positive performance fee (alongside satisfactory results in all other performance measures considered), also for the case where 4 lags in the information set are considered.

Finally, Figure 2 offers a visual description of the time variation in the weights investing in the four risky assets: the UK, German, Japanese, and Canadian bonds. The figure displays the weights for four strategies: the benchmark *RW* strategy, the NXA strategy, the $NXA_{Rest1\&2}$ strategy, and the NXA_{Lag2} strategy. As expected, the weights are very smooth over time for the *RW* strategy, and remain reasonably smooth for the other strategies, suggesting that transaction costs should not play a major role for any of the strategies examined.

Overall, the core result that the model conditioning on measures of bilateral external imbalances provides substantial out-of-sample 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 also when sensible economic restrictions are imposed on the forecasts of exchange rate returns. Moreover the result is fairly robust to lagging the information set available to the investor, with the possible exception of lagging as much as one year.[18]

6 Conclusions

This paper extends 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 the 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

[18] As a further robustness check, we examine the out-of-sample results when the benchmark model is a random walk with drift. This exercise is performed to assess whether the economic value obtained from using the NXA strategy is due to the predictive variable $nxa_t^{(i)}$ or simply to the inclusion of a constant term. This exercise suggests that the core results are qualitatively unaltered.

can earn profits from an asset allocation strategy that exploits this predictability. Our methodology for measuring economic value is based on a stylized mean-variance framework.

We use, as predictive variables, estimated measures of bilateral 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. 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 confirms the power of 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 that is required by the solvency of the country's intertemporal budget constraint.

A Appendix: Data

A.1 Data Sources

To construct our measures of cyclical external imbalances we collected data on exports, imports, external assets, external liabilities and net worth from March 1973 to December 2004. A breakdown of the sources is reported below.

US: we obtain quarterly data on exports and imports of goods and services from the Bureau of Economic Analysis (*U.S. International Transaction Accounts Data,* Table 1, lines 2 and 19, respectively). Annual data on external assets and liabilities are from Lane and Milesi-Ferretti (2007). The net worth series at annual frequency is from the Federal Reserve (*Flow of Funds,* Table B100, line 41).

UK: we collect quarterly data on exports and imports from the UK National Statistics (series KTMW and KTMX, respectively),[19] and annual data on external assets and liabilities from Lane and Milesi-Ferretti (2007). Quarterly data on bilateral exports and imports of goods and services between the US and the UK are from the BEA (*U.S. International Transactions Accounts Data* Table 11). The net worth series at annual frequency is from the UK National Statistics (series CGDA).

Germany: we construct quarterly data on exports and imports by summing up the series of goods and services provided by the International Monetary Fund (*International Financial Statistics* database, International Transaction Balance of Payments section). Annual data on foreign assets and liabilities are from Lane and Milesi-Ferretti (2007). Quarterly data on bilateral exports and imports of goods and services between the US and Germany are from the BEA (*U.S. International Transactions Accounts Data,* Table 11).[20] As proxy for the domestic wealth, we use the non-financial assets at annual frequency provided by the Deutsche Bundesbank and the Federal Statistical Office.

Japan: quarterly data on exports and imports are obtained from the Bank of Japan from 1973 to 1976, and the International Monetary Fund from 1977 to 2004 (*International Financial Statistics* database, International Transaction Balance of Payments section). Annual data on foreign assets and liabilities are from Lane and Milesi-Ferretti (2007). Quarterly data on bilateral exports and imports of goods and services between the US and Japan are from the BEA (*U.S. International Transactions Accounts Data*, Table 11). Annual data for the net worth series are from Japan Statistics Bureau (*Historical Statistics of Japan, National Accounts,* Table 3-14 and 3-32.

Canada: quarterly data on exports and imports are obtained from the International Monetary

[19] Although for some countries the unilateral transfer and income payment components of current accounts are not as small as for the US, we choose to consider, consistent with GR, only the goods and services components for our estimates of nxa_t. As a robustness check, however, we estimate nxa_t using all components of countries' current accounts and replicated a fraction of the empirical work without obtaining any qualitative difference in results.

[20] The BEA provides these figures from 1986 to 2004. From 1973 to 1985, we construct data assuming the same shares of exports and imports versus the US for the year 1986.

Fund (*International Financial Statistics* database, International Transaction Balance of Payments section). Annual data on foreign assets and liabilities are from Lane and Milesi-Ferretti (2007). Quarterly data on bilateral exports and imports of goods and services between US and Canada are from the BEA (*U.S. International Transactions Accounts Data,* Table 11). The source for the net worth series is the National Statistical Agency.

Note that all exports and imports series were gathered seasonally unadjusted and have been subsequently seasonally adjusted with simple dummy-variable regressions in the in-sample analysis. In the out-of-sample exercise, we seasonally adjust the series only for the available time period (recursively) to avoid any look ahead bias. All series of external assets and liabilities and net worth which were available only at annual frequency have been transformed to quarterly frequency by linear interpolation for the in-sample analysis and by linear extrapolation for the period January 1993 to December 2004 for the out-of-sample analysis. Again, this is to avoid any look-ahead bias.

A.2 Constructing Global External Imbalances and Bilateral Net Exports

We construct nxa_t, the global measures of cyclical imbalances, following GR. nxa_t is defined as a linear combination of stochastic trend-deviations of foreign exports, imports, assets and liabilities, normalized with respect to national wealth. Unlike GR and due to lack of official data on the composition of gross foreign asset positions for some of the countries in our sample, we did not attempt to construct quarterly estimates of these series. We rely instead on the work of Lane and Milesi-Ferretti (2007), who have constructed and made publicly available measures of foreign assets and liabilities at market value for many countries for the period 1970 to 2004.

First, we normalize the variables entering the construction of nxa_t using net worth. Second, we estimate the trend components of each variable as low-pass filter using the Hodrick-Prescott filter as in GR. As a robustness check, we compute the trend components with a simple quadratic trend, and obtain similar results.

By filtering out low-frequency trends, we are able to decompose each normalized variable into a deterministic trend component, and a stationary component, representing the stochastic deviations from the long-run estimated trend. For each country, the measure of external imbalances linearly combines these stationary components in assets, liabilities, exports and imports. The weights used for this combination take into account the relative share of exports/imports in the detrended net export, and the relative share of assets/liabilities in the detrended net foreign assets. Following GR, we replace the time-varying shares with their sample average values, and then take their absolute values to construct the country-specific global measures of external imbalances, nxa_t.

The global measure of cyclical external imbalances is computed as follows

$$nxa_t \equiv \frac{|\mu_t^a|}{|\mu_t^x|}\epsilon_t^a - \frac{|\mu_t^l|}{|\mu_t^x|}\epsilon_t^l + \epsilon_t^x - \frac{|\mu_t^m|}{|\mu_t^x|}\epsilon_t^m$$

where

$$\begin{aligned} \mu_t^a &= \frac{\bar{A}_t}{\bar{A}_t - \bar{L}_t}, \qquad \mu_t^l = \mu_t^a - 1 \\ \mu_t^x &= \frac{\bar{X}_t}{\bar{X}_t - \bar{M}_t}, \qquad \mu_t^m = \mu_t^x - 1 \end{aligned}$$

$\overline{Z} = \{\bar{A}_t, \bar{L}_t, \bar{X}_t, \bar{M}_t\}$ comprises external assets, external liabilities, exports and imports normalized with respect to net worth, ϵ_t^z is the stationary component we are interested in, the weight μ_t^a is the (trend) share of assets in the net foreign assets, and the weight μ_t^x is the (trend) share of exports in the trade balance. The weights are then normalized with respect to μ_t^x such that the weight on exports is unity, and nxa_t can be interpreted as the percentage increase in exports needed to restore a country's external equilibrium. Moreover, this normalization permits an easier comparison across countries.

Similarly, we construct the detrended net exports between the US and a foreign country i as

$$nx_t^{(i)} \equiv \epsilon_t^{x^{(i)}} - \frac{|\mu_t^{m^{(i)}}|}{|\mu_t^{x^{(i)}}|}\epsilon_t^{m^{(i)}} \tag{A.4}$$

where $\epsilon_t^{x^{(i)}}$ and $\epsilon_t^{m^{(i)}}$ are the stationary components of (log) bilateral exports and imports; and $\mu_t^{x^{(i)}}$ and $\mu_t^{m^{(i)}}$ are the (trend) shares of bilateral exports and imports in the bilateral trade balance.

B Appendix: Bootstrap Methods

B.1 Out-of-Sample Forecast Accuracy Test

In Table 2 we present the out-of sample forecast accuracy test for the predictive regression based on nxa_t, the global measure of US cyclical imbalances. The test is based on the MSE-*adjusted* statistic (MSE_a) for the null hypothesis that the driftless random walk model encompasses the model conditioning on nxa_t (Clark and West, 2007). Under the alternative hypothesis, the model exploiting the predictive information in nxa_t has lower mean square error (MSE) than the driftless random walk model. Given the relative small number of out-of-sample observations, we implement a bootstrap procedure to compute the one-sided p-value. In our case, the bootstrap exercise computes how often an economy in which there is no FX predictability would produce as much predictability as found in actual data.

Specifically, we impose a data generating process of no predictability and consider the overlapping block resampling scheme (e.g. Kunch, 1989; Politis and Romano, 1994; Hall, Horowitz and Jing, 1995; Politis and White, 2004). Let y_t be the dependent variable, and x_{t-1} the predictive variable. We proceed as follows:

1. Run the predictive regression $y_t = \alpha + \beta x_{t-1} + \varepsilon_t$, compute the MSE_a statistic as in equation (8), and set $\widetilde{y}_t = \widehat{\varepsilon}_t$.

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

3. Run the predictive regression $y_t^* = \alpha^* + \beta^* x_{t-1}^* + \varepsilon_t^*$, and compute the MSE_a^* statistic

4. Repeat $10,000$ times steps 2 and 3.

5. Determine the one-sided p-value by computing the proportional number of times that MSE_a^* is greater than MSE_a.

B.2 Small Sample Bias Correction

The small number of observations might cause bias in the parameter estimates. To take into account this effect, we consider a bootstrap procedure based on the overlapping block resampling scheme (e.g. Kunch, 1989; Politis and Romano, 1994; Hall, Horowitz and Jing, 1995; Politis and White, 2004). 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 $y_t = \alpha + \beta x_{t-1} + \varepsilon_t$ by least squares and obtain the estimates $\widehat{\alpha}$ and $\widehat{\beta}$.

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.[21]

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

Table 1. Summary Statistics

The table summarizes the descriptive statistics for the changes in total foreign assets Δa_t, foreign liabilities Δl_t, exports Δx_t, imports Δm_t, the global measure of cyclical imbalances nxa_t, the bilateral measure of US cyclical imbalances $nxa_t^{(i)}$, and the bilateral nominal exchange rate return with the US dollar as pricing currency $\Delta s_t^{(i)}$. The global measure nxa_t linearly combines stationary components in total foreign assets, liabilities, exports and imports as in Gourinchas and Rey (2007). The bilateral measure $nxa_t^{(i)}$ is estimated by regressing nxa_t for the US economy on the nxa_t for the foreign country i, and the bilateral detrended net exports between the US and the foreign country i. The data set covers quarterly data from March 1973 to December 2004. All statistics are expressed in percentage points.

	Δa_t	Δl_t	Δx_t	Δm_t	nxa_t	$nxa_t^{(i)}$	$\Delta s_t^{(i)}$
				US			
Mean	2.923	3.394	2.143	2.482	0.000		
Std Dev	2.215	1.444	4.634	4.976	16.04		
Skew	−0.639	−0.555	0.239	0.057	−0.156		
Kurtosis	2.076	2.632	3.499	3.519	1.841		
$Corr\,(z_t, z_{t-1})$	0.769	0.812	−0.256	0.089	0.936		
$Corr(z_t, z_{t-2})$	0.542	0.636	0.472	−0.181	0.852		
$Corr\,(z_t, z_{t-4})$	0.088	0.320	0.641	0.371	0.647		
$Corr\,(z_t, z_{t-8})$	−0.101	0.253	0.496	0.435	0.397		
$Corr\,(z_t, z_{t-16})$	−0.119	−0.156	0.516	0.525	−0.273		
				UK			
Mean	3.360	3.460	2.396	2.384	0.000	0.000	−0.201
Std Dev	2.507	2.247	4.863	4.798	10.73	7.019	5.183
Skew	−0.079	0.022	−0.058	0.402	0.276	0.251	−0.241
Kurtosis	2.852	2.617	4.801	2.824	2.803	2.646	3.424
$Corr\,(z_t, z_{t-1})$	0.745	0.750	−0.208	0.167	0.928	0.774	0.140
$Corr(z_t, z_{t-2})$	0.493	0.502	0.152	−0.244	0.865	0.719	−0.137
$Corr\,(z_t, z_{t-4})$	0.002	0.015	0.436	0.236	0.771	0.642	0.082
$Corr\,(z_t, z_{t-8})$	0.106	0.106	0.372	0.325	0.572	0.361	0.002
$Corr\,(z_t, z_{t-16})$	−0.076	−0.190	0.332	0.153	0.062	−0.053	−0.272
				Germany			
Mean	2.757	2.902	1.792	1.788	0.000	0.000	0.534
Std Dev	1.179	1.511	6.682	6.010	8.663	11.62	6.184
Skew	0.144	0.091	0.073	−0.061	0.464	−0.109	0.008
Kurtosis	2.983	2.703	2.515	3.892	2.489	1.831	2.661
$Corr\,(z_t, z_{t-1})$	0.778	0.743	−0.519	−0.210	0.938	0.946	0.032
$Corr(z_t, z_{t-2})$	0.561	0.489	0.329	−0.130	0.904	0.912	−0.150
$Corr\,(z_t, z_{t-4})$	0.131	−0.018	0.426	0.183	0.794	0.816	0.167
$Corr\,(z_t, z_{t-8})$	−0.043	0.077	0.413	0.179	0.510	0.564	0.070
$Corr\,(z_t, z_{t-16})$	−0.179	−0.055	0.316	0.053	−0.081	−0.040	−0.071

(continued)

Table 1. Summary Statistics *(continued)*

	Δa_t	Δl_t	Δx_t	Δm_t	nxa_t	$nxa_t^{(i)}$	$\Delta s_t^{(i)}$
				Japan			
Mean	2.624	2.602	1.545	1.482	0.000	0.000	0.751
Std Dev	3.772	4.127	7.658	7.451	10.23	10.23	6.256
Skew	0.396	0.534	−0.283	0.179	0.493	−0.822	0.494
Kurtosis	2.991	2.696	4.024	2.705	3.507	3.465	3.502
$Corr\,(z_t, z_{t-1})$	0.745	0.792	−0.113	0.242	0.892	0.932	0.099
$Corr(z_t, z_{t-2})$	0.507	0.597	0.036	0.142	0.781	0.856	−0.118
$Corr\,(z_t, z_{t-4})$	0.049	0.228	0.475	0.131	0.523	0.724	0.126
$Corr\,(z_t, z_{t-8})$	−0.036	0.182	0.368	−0.036	0.016	0.362	−0.007
$Corr\,(z_t, z_{t-16})$	−0.014	−0.240	0.115	−0.185	−0.392	−0.151	−0.226
				Canada			
Mean	2.732	2.268	2.297	2.236	0.000	0.000	−0.146
Std Dev	1.585	1.249	6.926	6.358	5.842	11.53	2.515
Skew	0.154	0.690	0.420	−0.280	0.140	−0.259	0.507
Kurtosis	3.166	3.828	2.842	2.583	2.739	4.101	3.890
$Corr\,(z_t, z_{t-1})$	0.863	0.871	−0.551	−0.267	0.830	0.738	0.068
$Corr(z_t, z_{t-2})$	0.728	0.744	0.469	0.070	0.767	0.673	0.007
$Corr\,(z_t, z_{t-4})$	0.480	0.504	0.706	0.671	0.610	0.579	0.099
$Corr\,(z_t, z_{t-8})$	0.297	0.392	0.687	0.629	0.398	0.397	−0.047
$Corr\,(z_t, z_{t-16})$	−0.099	0.129	0.687	0.698	0.076	−0.118	−0.077

Table 2. Forecasting US Trade-Weighted Exchange Rate Return

The table displays the in-sample estimates and the out-of-sample test of forecast accuracy for the predictive regression $\Delta_k s_{t+k} = \alpha + \beta nxa_t + \varepsilon_{t+k}$, where $\Delta_k s_{t+k} = s_{t+k} - s_t$ is the k-period US nominal effective exchange rate return, and nxa_t is the global measure of US cyclical imbalances. nxa_t linearly combines stationary components in total foreign assets, foreign liabilities, exports and imports as in Gourinchas and Rey (2007). R^2 is the in-sample coefficient of determination. MSE_a is the MSE-*adjusted* statistic (Clark and West, 2006) for the null hypothesis that the driftless random walk model encompasses the model conditioning on nxa_t. The estimates of β are reported divided by k to ease the comparison across forecast horizons. 95% confidence intervals are reported in parentheses, whereas one-sided *p-values* are given in square brackets. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The confidence intervals, the significance levels and the *p-values* are obtained by generating 10,000 time series by means of block bootstrap. The parameter estimates, the confidence intervals and $R^2$are computed using quarterly data from March 1973 to December 2004. The MSE_a statistic is based on a rolling window of 20 years and the out-of-sample period runs from March 1993 through December 2004.

k	1	2	3	4	8	12	16
β/k	-0.075^{***}	-0.077^{***}	-0.076^{***}	-0.073^{***}	-0.063^{***}	-0.046^{***}	-0.030^{***}
	(-0.107 -0.031)	(-0.109 -0.034)	(-0.107 -0.037)	(-0.104 -0.035)	(-0.095 -0.033)	(-0.070 -0.024)	(-0.049 -0.008)
R^2	0.12	0.23	0.34	0.37	0.44	0.35	0.21
MSE_a	[0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[0.08]

Table 3. Predictive Regression

The table reports the in-sample estimates for the predictive regression $\Delta_k s_{t+k}^{(i)} = \alpha + \beta nxa_t^{(i)} + \varepsilon_{t+k}$, where $\Delta_k s_{t+k}^{(i)} = s_{t+k}^{(i)} - s_t^{(i)}$ is the k-period bilateral nominal exchange rate return with the US dollar as pricing currency, and $nxa_t^{(i)}$ is the bilateral measure of US cyclical imbalances. R^2 is the in-sample coefficient of determination. The estimates of β are reported divided by k to ease the comparison across forecast horizons. 95% confidence intervals are reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The confidence intervals and the significance levels are obtained by generating 10,000 time series by means of block bootstrap. The analysis uses quarterly data from March 1973 to December 2004.

k	1	2	3	4	8	12	16
				USD/GBP			
β/k	-0.045	-0.034	-0.047	-0.048	-0.055	-0.060^*	-0.074^{**}
	(-0.146, 0.111)	(-0.129, 0.112)	(-0.131, 0.075)	(-0.130, 0.084)	(-0.141, 0.054)	(-0.150, 0.015)	(-0.158, -0.009)
R^2	0.01	0.01	0.01	0.02	0.03	0.06	0.15
				USD/EUR			
β/k	-0.134^{***}	-0.128^{***}	-0.127^{***}	-0.128^{***}	-0.113^{***}	-0.063^{***}	-0.058^{***}
	(-0.262, -0.052)	(-0.246, -0.049)	(-0.243, -0.048)	(-0.255, -0.054)	(-0.212, -0.049)	(-0.170, -0.041)	(-0.151, -0.035)
R^2	0.06	0.11	0.18	0.22	0.28	0.28	0.32
				USD/JPY			
β/k	-0.178^{***}	-0.172^{***}	-0.154^{**}	-0.142^{**}	-0.107^*	-0.059	-0.035
	(-0.300, -0.073)	(-0.271, -0.070)	(-0.225, -0.044)	(-0.207, -0.019)	(-0.1734 0.010)	(-0.128, 0.045)	(-0.094, 0.042)
R^2	0.09	0.14	0.18	0.20	0.22	0.11	0.06
				USD/CAD			
β_k/k	-0.007	-0.022	-0.022	-0.027	-0.040^{**}	-0.037^{**}	-0.030^*
	(-0.039, 0.062)	(-0.054, 0.038)	(-0.049, 0.034)	(-0.049, 0.025)	(-0.058, -0.002)	(-0.055, -0.001)	(-0.047, 0.001)
R^2	0.02	0.02	0.03	0.05	0.20	0.28	0.30

Table 4. Economic Value

The table displays the in-sample and out-of-sample portfolio performance of the *NXA* dynamic investment strategy relative to the *RW* strategy. The *RW* strategy forecasts exchange rate returns using the driftless random walk model. The *NXA* strategy exploits the predictive information in the bilateral measure of US cyclical imbalances relative to the UK, Germany, Japan and Canada. The strategy considers a US investor who dynamically rebalances 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. Each strategy maximizes expected returns subject to a given target volatility. Three target portfolio volatilities $\sigma_p^* = \{8\%, 10\%, 12\%\}$ are considered. The mean realized portfolio return μ_p, volatility σ_p, and Sharpe ratio SR_p are reported for each strategy. 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 the *RW* strategy to the *NXA* strategy. Θ measures the excess premium return of the *NXA* strategy relative to the *RW* strategy. τ^{be} is the break-even proportional transaction cost which cancels out the utility advantage of the *NXA* strategy against the *RW* strategy. μ_p and σ_p are reported in annualized percentage points, Φ and Θ are expressed in annual basis points, and τ^{be} in quarterly basis points. The in-sample analysis covers quarterly data from March 1973 to December 2004. The out-of-sample analysis uses a rolling window of 20 years and runs from March 1993 through December 2004.

	RW			*NXA*					
σ_p^*	μ_p	σ_p	SR_p	μ_p	σ_p	SR_p	Φ	Θ	τ^{be}
				In-Sample					
8%	13.4	9.0	0.70	14.9	8.7	0.90	148	142	134
10%	15.0	11.1	0.71	16.9	10.7	0.91	185	177	137
12%	16.6	13.3	0.71	18.8	12.7	0.91	222	212	141
				Out-of-Sample					
8%	12.9	9.9	0.88	14.5	7.8	1.32	160	155	153
10%	15.1	12.3	0.88	17.1	9.7	1.32	200	192	164
12%	17.2	14.8	0.88	19.6	11.7	1.32	241	230	175

Table 5. Economic Value and Small Sample Bias

The table displays the in-sample and out-of-sample portfolio performance of the *NXA* dynamic investment strategy relative to the *RW* strategy when parameter estimates are adjusted for small-sample bias using 10,000 time series by means of block bootstrap. The *RW* strategy forecasts exchange rate returns using the driftless random walk model. The *NXA* strategy exploits the predictive information in the bilateral measure of US cyclical imbalances relative to the UK, Germany, Japan and Canada. The strategy considers a US investor who dynamically rebalances 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. Each strategy maximizes expected returns subject to a given target volatility. Three target portfolio volatilities $\sigma_p^* = \{8\%, 10\%, 12\%\}$ are considered. The mean realized portfolio return μ_p, volatility σ_p, and Sharpe ratio SR_p are reported for each strategy. 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 the *RW* strategy to the *NXA* strategy. Θ measures the excess premium return of the *NXA* strategy relative to the *RW* strategy. τ^{be} is the break-even proportional transaction cost which cancels out the utility advantage of the *NXA* strategy against the *RW* strategy. μ_p and σ_p are reported in annualized percentage points, Φ and Θ are expressed in annual basis points, and τ^{be} in quarterly basis points. The in-sample analysis covers quarterly data from March 1973 to December 2004. The out-of-sample analysis uses a rolling window of 20 years and runs from March 1993 through December 2004.

	RW			*NXA*					
σ_p^*	μ_p	σ_p	SR_p	μ_p	σ_p	SR_p	Φ	Θ	τ^{be}
				In-Sample					
8%	13.4	9.0	0.70	15.0	8.7	0.90	151	145	136
10%	15.0	11.1	0.71	16.9	10.8	0.91	189	181	139
12%	16.6	13.3	0.71	18.9	12.8	0.91	227	217	143
				Out-of-Sample					
8%	12.9	9.9	0.88	15.1	7.8	1.38	220	212	190
10%	15.1	12.3	0.88	17.8	9.8	1.39	275	267	203
12%	17.2	14.8	0.88	20.5	11.7	1.39	331	315	216

Table 6. Economic Value and Economic Restrictions

The table displays the out-of-sample portfolio performance of the *NXA* dynamic investment strategy relative to the *RW* strategy when economically meaningful restrictions are imposed on the forecasts of the predictive regression underlying the *NXA* strategy (Campbell and Thompson, 2008). The *RW* strategy forecasts exchange rate returns using the driftless random walk model. The *NXA* strategy exploits the predictive information in the bilateral measure of US cyclical imbalances relative to the UK, Germany, Japan and Canada. The strategy considers a US investor who dynamically rebalances capital 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. Each strategy maximizes expected returns subject to a given target volatility. Three target portfolio volatilities $\sigma_p^* = \{8\%, 10\%, 12\%\}$ are considered. *Rest 1* denotes the economic restriction that the slope of the predictive regression is set to zero when it is estimated with positive sign. In *Rest 2* the forecast of the predictive regression is set to zero when it is sign is the same as the conditioning variable. In *Rest 1&2* both *Rest 1* and *Rest 2* are simultaneously imposed. The mean realized portfolio return μ_p, volatility σ_p, and Sharpe ratio SR_p are reported for each strategy. The performance fee 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 the *RW* strategy to the *NXA* strategy. Θ measures the excess premium return of the *NXA* strategy relative to the *RW* strategy. τ^{be} is the break-even proportional transaction cost which cancels out the utility advantage of the NXA strategy against the RW strategy. μ_p, and σ_p are reported in annualized percentage points, 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 March 1993 through December 2004.

	RW			*NXA*					
σ_p^*	μ_p	σ_p	SR_p	μ_p	σ_p	SR_p	Φ	Θ	τ^{be}
				Rest 1					
8%	12.9	9.9	0.88	14.5	7.8	1.32	157	152	153
10%	15.1	12.3	0.88	17.0	9.7	1.32	197	189	164
12%	17.2	14.8	0.88	19.6	11.6	1.32	236	225	175
				Rest 2					
8%	12.9	9.9	0.88	15.4	8.8	1.28	253	244	132
10%	15.1	12.3	0.88	18.2	10.9	1.28	316	304	136
12%	17.2	14.8	0.88	21.0	13.1	1.28	380	362	140
				Rest 1&2					
8%	12.9	9.9	0.88	15.4	8.8	1.28	250	241	131
10%	15.1	12.3	0.88	18.2	10.9	1.28	314	301	134
12%	17.2	14.8	0.88	21.0	13.1	1.28	375	358	138

Table 7. Economic Value in Real Time

The table displays the out-of-sample portfolio performance of the *NXA* dynamic investment strategy relative to the *RW* strategy when the conditioning variable in the predictive regression is released with a given delay. The *RW* strategy forecasts exchange rate returns using the driftless random walk model. The *NXA* strategy exploits the predictive information in the US bilateral measure of cyclical imbalances relative to the UK, Germany, Japan and Canada. The NXA_{Lag1} strategy uses the one-step ahead predictive regression. The NXA_{Lag2} strategy uses a predictive regression where the conditioning variable is available with a delay of 2 quarters. The NXA_{Lag4} strategy uses a predictive regression where the conditioning variable is available with a delay of 4 quarters. The strategy considers a US investor who dynamically rebalances capital every quarter between the domestic bond in US dollar and four foreign bonds in foreign currencies. Each strategy maximizes expected returns subject to a given target volatility. Three target portfolio volatilities $\sigma_p^* = \{8\%, 10\%, 12\%\}$ are considered. *Rest 1* denotes the economic restriction that the slope of the predictive regression is set to zero when it is estimated with positive sign. In *Rest 2* the forecast of the predictive regression is set to zero when it is sign is the same as the conditioning variable. In *Rest 1&2* both *Rest 1* and *Rest 2* are simultaneously imposed. The mean realized portfolio return μ_p, volatility σ_p, and Sharpe ratio SR_p are reported for each strategy. 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 the *RW* strategy to the *NXA* strategy. Θ measures the excess premium return of the *NXA* strategy relative to the *RW* strategy. τ^{be} is the break-even proportional transaction cost which cancels out the utility advantage of the *NXA* strategy against the *RW* strategy. μ_p and σ_p are reported in annualized percentage points, 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 March 1993 through December 2004.

	NXA_{Lag1}			NXA_{Lag2}			NXA_{Lag4}		
σ_p^*	Φ	Θ	τ^{be}	Φ	Θ	τ^{be}	Φ	Θ	τ^{be}
				No Rest					
8%	160	155	153	157	154	64	−93	−91	–
10%	200	192	164	197	191	66	−117	−113	–
12%	241	230	175	236	228	68	−140	−134	–
				Rest 1					
8%	157	152	153	166	162	70	−96	−93	–
10%	197	189	164	207	201	73	−120	−115	–
12%	236	225	175	249	240	75	−143	−137	–
				Rest 2					
8%	253	244	132	343	331	133	125	119	86
10%	316	304	136	429	411	136	156	148	92
12%	380	362	140	514	491	137	187	176	98
				Rest 1&2					
8%	250	241	131	343	331	133	122	117	85
10%	314	301	134	429	411	136	153	145	91
12%	375	358	138	514	491	140	184	173	96

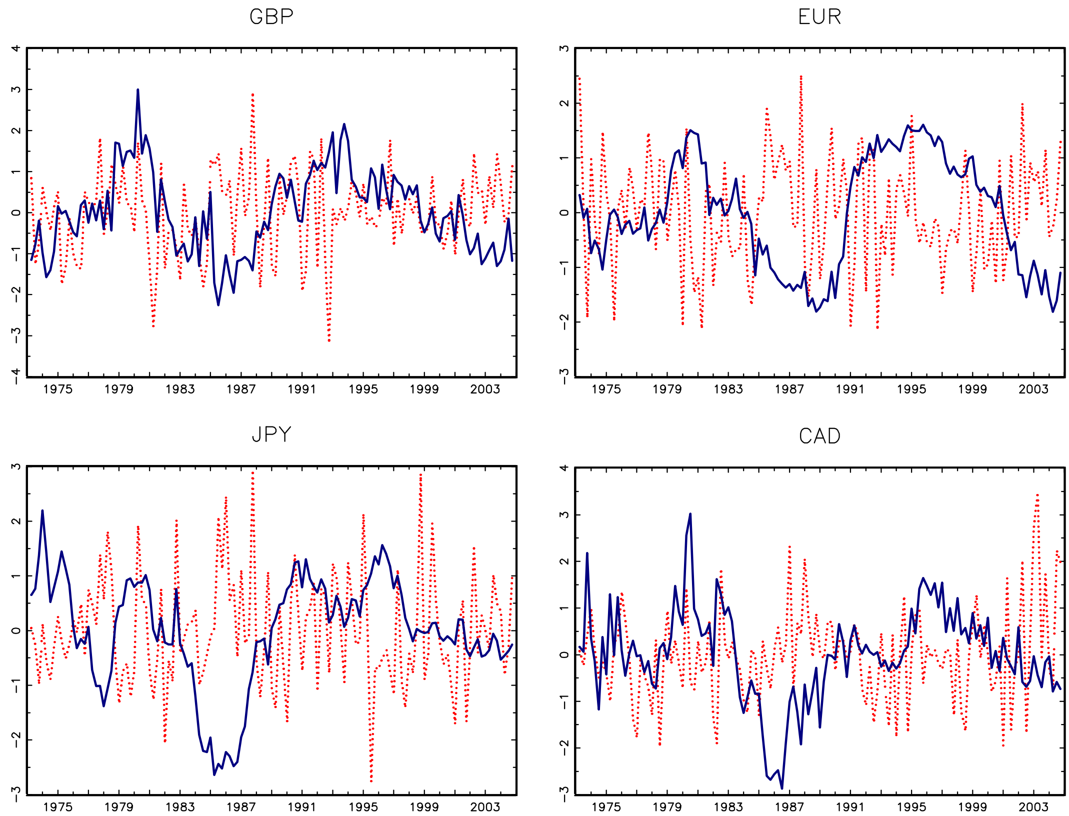

Figure 1. Exchange Rate Returns and Bilateral Cyclical Imbalances

The figure displays $\Delta s_{t+1}^{(i)}$ (dotted line) and $nxa_t^{(i)}$ (solid line). $\Delta s_t^{(i)}$ is the bilateral nominal exchange rate return for the British pound (GBP), the Deutsche mark/Euro (EUR), the Japanese yen (JPY) and the Canadian dollar (CAD) with the US dollar (USD) as pricing currency; $nxa_t^{(i)}$ is a bilateral measure of US cyclical imbalances relative to the UK, Germany, Japan and Canada, respectively. The data set comprises quarterly data ranging from March 1973 through December 2004. The time series are normalized to have zero mean and unit standard deviation.

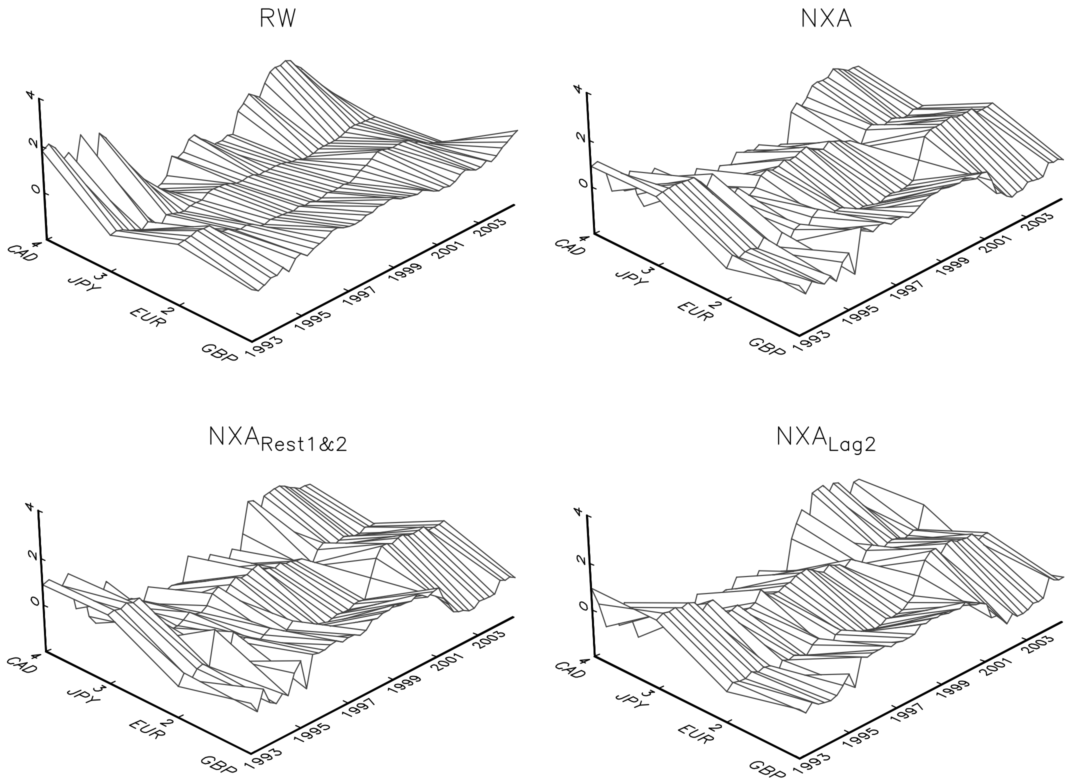

Figure 2. Out-of-Sample Portfolio Weights

The figure displays the out-of-sample time variation in the optimal portfolio weights for dynamic investment strategies when the target volatility equals 10%. The *RW* strategy is based on the driftless random walk model whereas the *NXA* strategy exploits the predictive information in the bilateral measure of US cyclical imbalances relative to the UK, Germany, Japan and Canada. The $NXA_{Rest1\&2}$ strategy denotes the *NXA* strategy when the economic restrictions *Rest 1* and *Rest 2* are simultaneously imposed. The NXA_{Lag2} strategy refers to the *NXA* strategy when the predictive variable is assumed to be released with a delay of two quarters. The out-of-sample analysis uses a rolling window of 20 years and runs from March 1993 through December 2004.

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