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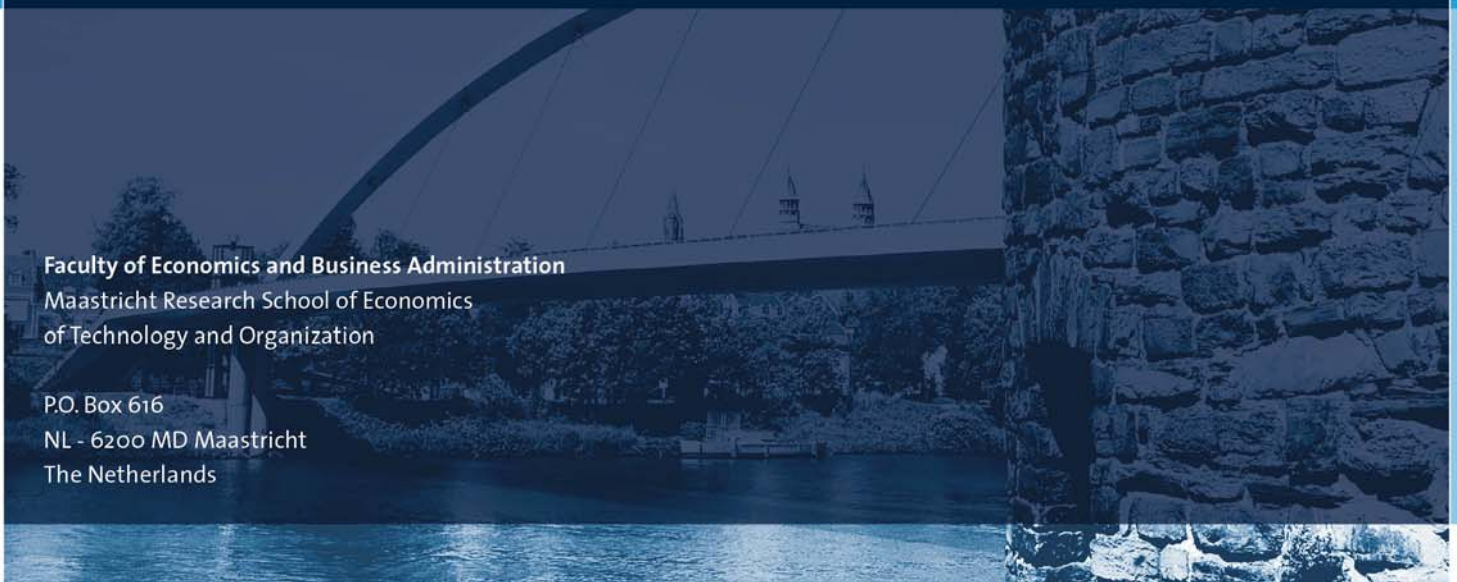Joan Muysken

**International Portfolio Balance –
Modeling the External Adjustment
Process**

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International Portfolio Balance - Modeling the External Adjustment Process

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Abstract

Unprecedented growth in private cross-border asset trade and asymmetric international balance sheets are well-documented stylized facts of financial integration. Moreover, we observe that current accounts are no longer the number one determinant of external balances. Advancing the work of Blanchard et al. (2005), this paper develops a portfolio-balance model that recognizes these stylized facts and shows how they influence the joint dynamics of the current account, the exchange rate and relative asset prices. Calibrating the model to the external adjustment process of the US, the model produces results that are broadly consistent with recent empirical trends. In particular, we find that the composition of its international balance sheet helps the US to better cope with external shocks.

JEL Classification: F32, F36, F37, F47

Keywords: portfolio-balance models, external adjustment process, international financial integration

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1 Introduction

International financial integration is one of the key trends that shape the global economy and its empirical and theoretical understanding has moved to the fore among academics and policymakers. Three stylized facts of international financial integration stand out. We revisit them shortly:

1. The past two decades have witnessed an unprecedented growth in private international asset trade. As a consequence, cross-border holdings of financial assets are reaching all-time highs. Figure 1a shows that between 1980 and 2006, aggregate gross foreign assets and liabilities (scaled by GDP) have increased almost sixfold for OECD countries, sevenfold for Euro area countries and more than fivefold for Asian countries.[1] These numbers are evidence that portfolio diversification has become the main motive for international asset flows. Investors increasingly seek foreign asset markets to diversify investment risk. Intertemporal lending and borrowing play a subordinated role.

2. The composition of gross foreign assets and liabilities in terms of equity and bonds, geographical allocation and currency denomination is more heterogeneous than ever before. Figure 1b demonstrates the heterogeneity of the international balance sheet by splitting foreign assets and liabilities into equity and bond holdings. We find, for instance, that in 2006, the US is short in bond and long in equity holdings, while most Asian and oil-exporting countries hold considerable amounts of net foreign bonds.

3. We observe an apparent disconnect between the current account and changes in the net international investment position (NIIP) of a country. Before the onset of financial globalization, changes in a country's NIIP were primarily determined by capital flows stemming from current account imbalances. Countries that were running persistent current account surpluses improved their NIIP, while countries with persistent current account deficits worsened their NIIP vis-à-vis the rest of the world (RW). In a financially integrated world, however, exchange rate and asset price dynamics generate revaluations of existing stocks of foreign assets that are as important as current account imbalances in shaping a country's NIIP. In light of Stylized Fact 1, the impact of the valuation channels of exchange rate adjustment and asset price fluctuation has been considerably leveraged in the last two decades. Figure 1c illustrates the disconnect using year-by-year correlation coefficients between current accounts and changes in NIIPs of all countries mentioned in footnote 1. It is apparent that the current account is no longer the number one determinant of changes in a country's NIIP. The correlation is vanishing, particularly in recent years.

The characteristics of international financial integration have come under close scrutiny in recent years because of their far-reaching implications for the nature of international risk-sharing and

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[1]OECD countries consist of Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Mexico, Netherlands, New Zealand, Norway, Spain, Sweden, UK and the US. Euro area countries consist of Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands and Spain. Asian countries consist of China, Indonesia, Japan, Korea, Singapore, Taiwan and Thailand.

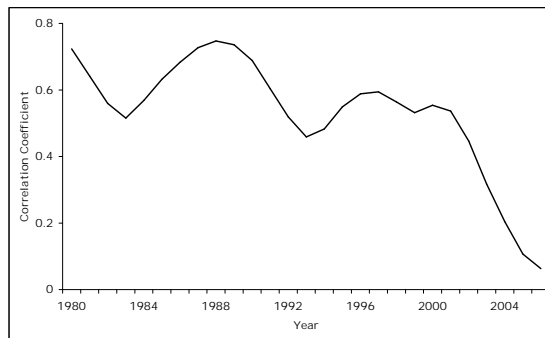**Figure 1:** Stylized facts of international financial integration, 1980-2006
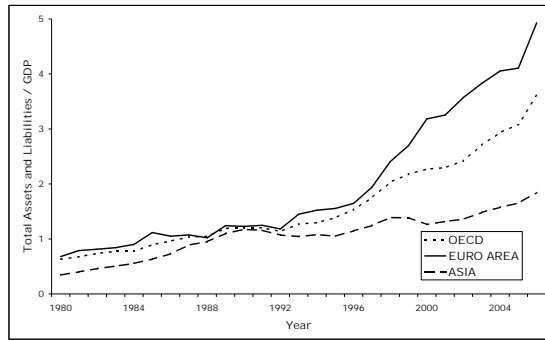
(a) Cross-border asset trade
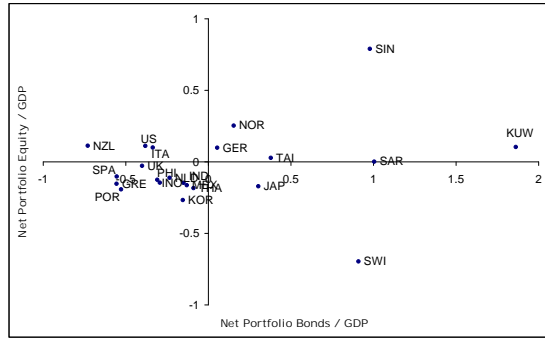
(b) Heterogeneous international balance sheet composition

(c) Disconnect of the current account and changes in NIIP

Data source: Lane and Milesi-Ferretti (2007). The correlation coefficient in Figure 1c is the trend component of the series using the Hodrick-Prescott filter with $\lambda = 6.25$.

adjustment processes. Empirically, the stylized facts listed here are well-documented in the literature that has been growing in the last decade, paralleling the widening current account deficits of the US. See, for instance, the series of seminal work by Lane and Milesi-Ferretti (2001, 2003, 2005, 2007). What remains relatively unexplored is the modeling of the international adjustment process in a globalized world. What forces are in place and how do they interact to govern a country with an initial current account deficit to long-term national solvency? What is the relative role of asset prices and exchange rates and do they have the potential to mitigate the necessary current account adjustments of a debtor country on its path to external balance? Any model that seeks to answer these questions needs to combine the complex interplay between asset price and exchange rate movements, valuation effects on NIIPs and current account (im)balances with the stylized facts that characterize today's integrated financial markets. This is the focus of the present paper. We develop a portfolio-balance model that builds on the early contributions of Branson (1979), Henderson and Rogoff (1982) and Kouri (1983) and advances the more recent work of Blanchard, Giavazzi and Sa (2005, hereinafter BGS) in a number of ways. Portfolio-balance models provide a natural starting point to analyze the external adjustment process in a financially integrated world. This class of models puts portfolio-balancing wealth-holders in the center of the analysis and allows studying the ensuing dynamics of large cross-country investment positions (Stylized Fact 1). Paraphrasing Obstfeld (2007), the need for a portfolio-balance approach when modeling the external adjustment process has become acute as asset trade expands.

In the early contributions to portfolio-balance theory, exchange rate movements constitute the unique channel of external adjustment. Given supply and demand in the markets of domestic and foreign assets, the exchange rate is determined in the short-run equilibrium process, from where it feeds back onto itself through the determination of the current account and concomitant international wealth transfers. Thus, the early versions of portfolio-balance theory neglect the valuation channel of exchange rate adjustments and asset price movements altogether and fail to account for Stylized Facts 2 and 3.

BGS take a first step in modifying the portfolio-balance theory to better cope with financially integrated markets. They consider US external imbalances and develop a model where changes in the NIIP of the US and RW are the sum of the current account and exchange-rate induced capital gains. In the spirit of earlier portfolio-balance models, exchange rate changes remain the unique equilibrating force, although they have been assigned a dual role in the external adjustment process. This is a clear limitation of the BGS model. It omits the vital role asset prices play in the external adjustment process, and thus partly fails to account for Stylized Fact 3. Moreover, BGS consider US and RW asset markets in their aggregate form without discriminating the risk-return characteristics of different asset classes. Rey (2005) rightly points out in her discussion of the BGS paper that reality looks different. US foreign assets and liabilities include both equity and bonds, and in fact, in very asymmetric compositions. Foreign assets are tilted towards risky equity investments, while liabilities are dominated by low-yielding treasury bonds. As a consequence, BGS ignore that the external adjustment process depends

on relative return differentials as implied by Stylized Fact 2.

This paper develops an advanced version of the BGS model. Like BGS, we calibrate our portfolio-balance model to match the external imbalances of the US. Although the model is applicable to any country, we opt for modeling the US situation for two reasons. First, it allows a direct comparison of our results with BGS, and second, it provides an interesting case to study - in 2006 the US external deficit reached an historically unparalleled level of more than 6 percent of GDP.

One of the main improvements of our portfolio-balance model on the BGS model is the split of US and RW asset markets into equity and bond markets. It allows us to model explicitly the dynamics of exchange rates and relative asset prices as required for Stylized Fact 3 and enables us to account for international balance sheet asymmetries of Stylized Fact 2.

Another, related and innovative, feature of our model is the inclusion of wealth dynamics. Bernanke (2005) emphasizes in his discussion of the BGS model that the exogenous treatment of asset values is the most important omission of the BGS model since it precludes any endogenous evolution of wealth due to changes in asset prices as a source of current account dynamics. In contrast, we include relative asset prices and ensuing wealth and consumption dynamics as an integral part of the model and introduce them as an alternative channel to moderate the US external deficit.

Our model addresses many relevant issues of financially integrated markets. However we stress from the outset that the model is not capable of providing a complete description of the world. Rather it is our intention to deliver a partial, but concise, framework within which to analyze the joint dynamics of the current account, the exchange rate and relative asset prices and to produce results that are consistent with recent empirical trends. As such our model stands as an alternative to the more comprehensive class of open-economy dynamic general equilibrium models. Research into this class of models has been initiated by Obstfeld and Rogoff (1995), who provide a two-country framework that integrates exchange rate dynamics and the current account. Their model and those that followed embody the main elements of the intertemporal approach to the current account along with nominal rigidities and market imperfections. For a survey of these models, see Lane (2001). More recently and in light of proceeding financial integration, a growing literature on dynamic general equilibrium models has directed attention to the question of how investors make asset allocation decisions across countries and currencies. See the survey by Obstfeld (2007) and references therein for attempts at general-equilibrium models of portfolios in a world economy. Despite these interesting attempts, we believe that partial theories have their own virtue e.g. they do not have to rely on linearization methods to render complex non-linearities of the model tractable (see also Krugman, 2000, and Buiter, 2009).

Empirical work on the valuation effect of exchange rate and asset price movements remains largely confined to a small set of countries for which detailed statistical data on valuation components are available, e.g. the US (Gourinchas and Rey, 2007a,b, Lane and Milesi-Ferretti, 2005, and Tille, 2003) or Australia (Gourinchas, 2008). For other countries, overall valuation gains

need to be estimated indirectly by combining both stock and flow data and its decomposition into exchange rate and relative asset price effects approximated by a portfolio-weighted basket of exchange rates and equity-market indices, e.g. Switzerland (Stoffels and Tille, 2007). Most important for our model of the external adjustment process is that all of these studies find conclusive evidence that valuation gains are not randomly at work. Gourinchas and Rey (2007b) employ the intertemporal approach to the current account which suggests that any movement in NIIP must predict either future portfolio returns or future net export growth. For the US, they find that the valuation channel is stabilizing in nature and contributes around 30 percent of the cyclical (deviation from slow moving trends) process of international adjustment. Their findings have asset-pricing implications: external imbalances forecast net foreign portfolio returns one quarter to two years ahead. Similarly, Lane and Milesi-Ferretti (2005) establish considerable empirical support for stabilizing patterns of exchange rate and asset price movements. While the US net foreign asset position deteriorates, US foreign assets earn consistently higher rates of return than paid out on foreign liabilities. The rate of return differentials are asset price and exchange rate induced. Our portfolio-balance model derives its relevance from these observed empirical regularities by providing potential explanations. The opposite pattern emerges for Switzerland. As a small and highly integrated economy, Switzerland stands out as a sizable creditor country with persistent current account surpluses that averaged 12 percent of GDP since 1999. Yet, their NIIP marginally narrowed from 128 percent of GDP in 1999 to 114 percent of GDP in 2005. Stoffels and Tille (2007) find that the apparent discrepancy can be (partly) attributed to exchange rate and asset price valuation losses over the observed time horizon. For Australia the picture is less clear cut. Gourinchas (2008) shows that exchange rate and asset price valuation are equally important for the external adjustment process, but no convincing pattern evolves in the data.

Having established in the empirical literature that US investors earn excess rates of return on their foreign assets, Gourinchas and Rey (2007a) disaggregate these excess returns into two components: a return discount within each asset class and a composition effect due to international balance sheet asymmetries. They find that between a quarter and a third of current excess returns can be explained by the composition effect, the remainder by the return discount. Their findings substantiate the need to properly include Stylized Fact 2 in our model. Curcuru et al. (2007) introduce a third effect to the discussion, the timing of reshuffling across different asset classes, which they regard as a measure of investment skills. Their study confirms a positive composition effect that derives from the risk-seeking structure of the US external positions, but claims that it is neutralized by a superior performance of US asset markets vis-à-vis the RW. Moreover, the return foreigners earn in the US would have been even higher (by about 0.70 percent per year) if not for their inferior timing and investment skills.

A related strand of literature concerns the wealth effect on the trade balance. While its empirical treatment is scarce in the literature, two studies provide insightful results and advocate the inclusion of the wealth effect in our model. Fratzscher et al. (2007) investigate the relative importance of asset prices (as a proxy for US financial wealth) for the US current account.

Using Bayesian estimation techniques, they show that asset prices account for up to 32 percent of movements in the US current account. In contrast, real exchange rates account for only around 7 percent. Holinski and Vermeulen (2009) extend the study to a sample of 29 countries and cast the analysis into a global macroeconometric model. They find the wealth effect at work for the majority of countries. Most notably, they find in the long-run a real equity price elasticity of the trade balance of minus one-third for the US, minus one-sixth for the UK and minus one-eigth for Japan, respectively. We include the wealth effect in our analysis, following Bernanke (2005).

The rest of the paper is organized as follows. Section 2 introduces relevant concepts, the derivation of the model and its behavior in the steady state and along the transitory path. In Section 3, we calibrate the model to the situation of the US and undertake a number of simulation studies to put evidence on the model's ability to reproduce recent empirical findings. Section 4 concludes.

2   Modeling the external adjustment

In this section, we develop our portfolio-balance model that meets the stylized facts shown in Figure 1. Our model advances the work of BGS, and whenever deemed necessary we shall point out both models' similarities and differences. The building assumption of the BGS analysis is that of imperfect substitutability between assets. For simplicity, we will focus on the case where the degree of substitutability is zero (more on that below). The model is cast in discrete time, but for notational convenience, we will suppress the time index, t, when there is no confusion. Similar to BGS, the model can be summarized in two equilibrium relations. The first relation concerns equilibrium in our four asset markets, US bond and equity markets and RW bond and equity markets, and provides the equilibrium set of relative prices, e, P and P^*, conditional on the net foreign debt position. We refer to it as the *portfolio balance relation*. The second relation accounts for the dynamic feedback of these relative prices on the accumulation of net foreign debt. We refer to it as the *current account balance relation* and elaborate both relations below.

2.1   Introduction of relevant concepts

Think of two countries, domestic and foreign, or the US and RW, which both have bond and equity markets. We denote the outstanding stock of US bonds and equity by B and E, respectively, and the outstanding stock of RW bonds and equity by B^* and E^*, respectively.[2] All assets are denominated in local currency. Moreover, P is the price of equity relative to bonds in the US, and P^* the corresponding relative price in the RW. The exchange rate, e, is defined as the price of foreign currency in terms of the US dollar (such that an increase in the exchange

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[2]Note that, for reasons of analytical tractability, we exclude currencies as asset classes. They are of minor relevance in the current context. This is in contrast to the early work on portfolio-balance models by Branson (1979), Henderson and Rogoff (1982) and Kouri (1983), but in line with BGS.

rate denotes a depreciation of the US dollar). Note that this leaves us with three relative prices, P, P^* and e, to uniquely identify the price system of all four assets. We use subscripts to show which party holds the asset

$$B = B_{US} + B_{RW} \tag{1a}$$

$$B^* = B^*_{US} + B^*_{RW} \tag{1b}$$

$$PE = PE_{US} + PE_{RW} \tag{1c}$$

$$P^*E^* = P^*E^*_{US} + P^*E^*_{RW}. \tag{1d}$$

We can think of (1a-d) as equilibrium in our four financial markets. The left-hand side constitutes the supply of assets in each market and the right-hand side the corresponding demand for these assets by both US and foreign investors.

Let W denote the financial wealth of US investors, measured in units of US goods, and W^* that of RW investors, measured in units of foreign goods, and define financial wealth as the sum of all asset holdings

$$W = B_{US} + PE_{US} + e[B^*_{US} + P^*E^*_{US}] \tag{2a}$$

$$W^* = B^*_{RW} + P^*E^*_{RW} + [B_{RW} + PE_{RW}]/e. \tag{2b}$$

Assume further that US and foreign investors want to allocate their wealth between the individual markets according to a given set of asset preferences, which are labeled with α-shares for US investors and β-shares for RW investors. These preferences

$$B_{US} = \alpha_B W, \qquad PE_{US} = \alpha_E W, \tag{3a}$$

$$B^*_{US} = \alpha_{B^*} W/e, \qquad P^*E^*_{US} = \alpha_{E^*} W/e, \tag{3b}$$

$$B^*_{RW} = \beta_{B^*} W^*, \qquad P^*E^*_{RW} = \beta_{E^*} W^*, \tag{3c}$$

$$B_{RW} = \beta_B W^* e, \qquad PE_{RW} = \beta_E W^* e. \tag{3d}$$

are postulated in (3a-b) for US investors and in (3c-d) for RW investors. Total US and RW wealth is allocated over the four asset classes such that the α- and β-shares add up to unity. An important point to note is that we assume that these asset preferences lead to home bias in US and RW portfolios. More precisely, asset home bias implies that the wealth shares allocated to own-country assets is greater than one , $(\alpha_E + \alpha_B) + (\beta_{E^*} + \beta_{B^*}) > 1$.

Additionally, we introduce in (3a-d) the zero substitutability assumption to the model. For now, we abstain from modeling the wealth shares as a function of expected return differentials, but assume that every marginal unit of wealth is invested in the same way as the average unit according to investors' asset preferences. This assumption is innocuous to the steady state behavior of our model, but affects the transitory path between two steady states. We introduce the case of rational expectations and imperfect, but non-zero, asset substitutability

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in the appendix.

Substituting (3a-b) in (2a), and (3c-d) in (2b) allows expressing US and foreign wealth and relative equity prices as functions of the exchange rate e (conditional on the outstanding stocks of US and RW equity and bonds, B, E, B^* and E^*). Hence we obtain

$$W = (\beta_{B^*}B - \beta_B B^* e)/\Omega, \tag{4}$$

$$W^* = (\alpha_B B^* - \alpha_{B^*}B/e)/\Omega, \tag{5}$$

and

$$P = (1/E)[(\alpha_E \beta_{B^*} - \alpha_{B^*}\beta_E)B + (\alpha_B \beta_E - \alpha_E \beta_B)B^* e]/\Omega, \tag{6}$$

$$P^* = (1/E^*)[(\alpha_{E^*}\beta_{B^*} - \alpha_{B^*}\beta_{E^*})B/e + (\alpha_B \beta_{E^*} - \alpha_{E^*}\beta_B)B^*]/\Omega, \tag{7}$$

with $\Omega = \alpha_B \beta_{B^*} - \alpha_{B^*}\beta_B$. Since due to portfolio home bias $\alpha_B > \alpha_{B^*}$ and $\beta_{B^*} > \beta_B$, we have $\Omega > 0$. From (6) and (7), it becomes immediately apparent that in both countries relative equity prices are negative functions of outstanding equity stocks. Moreover, for reasonable asset preferences, e.g. those that we find in the data below, relative equity prices are positive functions of outstanding domestic bond stocks. Another interesting observation is that the sign of the covariances between the exchange rate, e, and relative equity prices, P and P^*, is ambiguous. Signs depend on the preference parameters, the signs of $(\alpha_B \beta_E - \alpha_E \beta_B)$ and $(\alpha_{E^*}\beta_{B^*} - \alpha_{B^*}\beta_{E^*})$.

We are now able to develop a portfolio-balance model that allows studying the joint dynamics of the exchange rate, relative asset prices and the current account.

2.2 Portfolio Balance

Equilibrium in our four asset markets can be easily derived from the concepts introduced above. Financial markets clear at all times. In case of any disturbance, for instance, caused by cross-border wealth transfers, the relative prices, e, P and P^*, move to yield short-run equilibrium in all four markets simultaneously. Since we are interested in how the external adjustment process impacts equilibrium in financial markets, we need to link the short-run equilibrium exchange rate, e, with the net foreign debt position of the US, F. The relative equity prices, P and P^*, follow as functions of the exchange rate according to (6) and (7). In our analysis the net foreign debt position of the US is given as the difference between US foreign liabilities and foreign assets at market value:

$$F = B_{RW} + PE_{RW} - e(B_{US}^* + P^* E_{US}^*). \tag{8}$$

Using $F = B + PE - W$, we can derive the portfolio balance relation between net foreign debt F and the exchange rate e as

$$F = \{[(1 - \alpha_E)\beta_B + \beta_E \alpha_B] B^* e - [(1 - \alpha_E - \alpha_B)\beta_{B^*} + (\beta_E + \beta_B)\alpha_{B^*}] B\}/\Omega. \tag{9}$$

The portfolio balance relation, together with (6) and (7), provides the set of relative prices, e, P and P^*, that yield equilibrium in financial markets for given levels of US net foreign debt. This is the analogon to the portfolio balance curve in the analysis of BGS, but we have endogenized the shifts in the curve that happen in the BGS model due to exogenous changes in asset values. That is, our portfolio balance relation recognizes asset price valuation effects. The slope of the relation between the exchange rate and net foreign debt becomes

$$\frac{de}{dF} = \frac{\Omega}{[(1 - \alpha_E)\beta_B + \beta_E \alpha_B]B^*}. \tag{10}$$

The slope is positive whenever $\Omega > 0$, which coincides with the presence of portfolio home bias.[3] Under this condition, an increase in net foreign debt is associated with a depreciation of the exchange rate. The increase in net foreign debt constitutes a wealth transfer from the US to the rest of the world. Portfolio home bias implies that the wealth transfer leads to a decline in the US demand for US equity and bonds that exceeds the concomitant increase in the foreign demand for these assets. As a consequence, there is excess supply of US equity and bonds at the initial exchange rate. To restore equilibrium on all four asset markets, the relative price of US equity and bonds needs to fall, hence the exchange rate needs to depreciate. To summarize, the accumulation of net foreign debt causes changes in relative asset prices according to (6), (7) and (10), which are caused by both, wealth effects, as W and W^* change, and substitution effects, as US and foreign investors reshuffle their investment positions to achieve portfolio balance.

2.3 Current Account Balance

The second equilibrium condition defines how the relative prices, e, P and P^*, feed back on the accumulation of net foreign debt. Simplifying, the accumulation of net foreign debt consists of three components: the trade deficit (TD), net factor payments (rF) and valuation gains (VG) on the existing stock of gross foreign assets and liabilities

$$F_{+1} - F = TD_{+1} + rF_{+1} - VG_{+1}. \tag{12}$$

First, we need to define the US trade deficit

$$TD(e, W(e), W^*(e), s) \quad \text{with} \quad TD_e < 0, TD_W > 0, TD_{W^*} < 0, TD_s > 0 \tag{13}$$

as a function of the exchange rate, US and foreign wealth and a shift parameter, s. In particular, we assume that exchange rate depreciation and an increase in foreign wealth reduce the US trade deficit, while an increase in US wealth increases the own trade deficit. Important to note is that (4) and (5) define US and foreign wealth as functions of the exchange rate and we find that $W_e < 0$ and $W_e^* > 0$ hold. Thus in the presence of wealth effects, an exchange rate depreciation

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[3]Note the analogy with BGS from (10). Assuming only one asset class in the US and RW and accordingly only preferences over domestic and foreign assets, we can set $\alpha_E = \alpha_B = \alpha$, $\alpha_{E^*} = \alpha_{B^*} = (1 - \alpha)$, $\beta_{E^*} = \beta_{B^*} = \beta$ and $\beta_E = \beta_B = (1 - \beta)$ to obtain the same slope for the portfolio balance relation as in BGS.

narrows the trade deficit directly through the common expenditure switching mechanism, but also indirectly through its impact on domestic and foreign wealth. The importance of the wealth effect is stressed in recent empirical work as we mentioned above and recognized in our model. The shift parameter, s, captures all exogenous influences on the trade deficit, i.e. changes in relative productivity or the taste for goods. Substituting the trade deficit in the current account balance relation (12), we now are in a position to elaborate on the returns on assets and the valuation gains. Therefore the current account balance relation is elaborated as follows

$$
\begin{aligned}
F_{+1} - F = & r_B B_{RW} + [(1 + r_E)(P_{+1}/P) - 1] P E_{RW} - [(1 + r_{B^*})(e_{+1}/e) - 1] e B_{US}^* \\
& - \left[(1 + r_{E^*})(e_{+1}/e)(P_{+1}^*/P^*) - 1\right] e P^* E_{US}^* + TD(e_{+1}, W_{+1}, W_{+1}^*, s_{+1}).
\end{aligned} \tag{14}
$$

(14) shows that the change in net foreign debt derives from asset price and exchange rate induced revaluations of the existing stocks of gross foreign liabilities (first and second terms) and gross foreign assets (third and fourth terms) and the trade balance deficit. r_E, r_B, r_{E^*} and r_{B^*} are best understood as the rates of return on US equity and bonds and RW equity and bonds that prevail in the steady state. This is not to be confused with the endogenized total return on US and RW equity, which is the sum of these steady state returns and relative equity price changes, $[(1 + r_E)(P_{+1}/P) - 1]$ and $[(1 + r_{E^*})(P_{+1}^*/P^*) - 1]$, respectively.

The current account balance relation captures many of the earlier introduced innovations that set our model apart from the work of BGS. First, it clearly shows that valuation gains on accumulated existing stocks of foreign assets and liabilities have three sources, changes in e, P and P^*. Second, it allows for international balance sheet heterogeneity and related risk-return characteristics to exert its influence on the accumulation of net foreign debt, and third, it includes the wealth effect as a determinant of the trade deficit. In the steady state, relative prices, e, P and P^* settle at their equilibrium values, valuation gains are absent and we can obtain the steady state current account balance relation from (14) as

$$
-rF = [(r' - r)\alpha_B + (r^* - r)\beta_B/\Omega]B^* e - [(r' - r)\alpha_{B^*} + (r^* - r)\beta_{B^*}/\Omega]B + TD(e, W, W^*, s) \tag{15}
$$

with an internal rate of return r and

$$
(r' - r) = [(r_B - r)\beta_B + (r_E - r)\beta_E],
$$

$$
(r^* - r) = [(r_{B^*} - r)\alpha_{B^*} + (r_{E^*} - r)\alpha_{E^*}].
$$

(15) is comparable to the current account balance relation of BGS, when all rates of return, r_E, r_B, r_{E^*} and r_{B^*}, are equal to the internal rate of return r.[4] Under this condition, (15) simplifies

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[4]The internal rate of return is introduced to reduce the notational burden. It is best understood as the weighted average of individual rates of return, r_E, r_B, r_{E^*} and r_{B^*}.

to the standard steady state equation for the current account

$$-rF = TD(e, W, W^*, s) \qquad (16)$$

with slope

$$\frac{de}{dF} = -\frac{r}{TD_e}. \qquad (17)$$

Our current account balance relation is upward sloping since $TD_e < 0$ and flatter than the one of BGS due to the inclusion of the wealth effects. In the steady state, the trade balance exactly offsets the interest payments on net foreign debt and valuation effects disappear. Thus, while valuation effects govern an economy from one steady state to another, it is the trade balance channel of the exchange rate and its expenditure switching/reducing mechanism that ultimately balances the current account.

2.4 Steady states and transitory dynamics

Figure 2 plots the portfolio and current account balance relations. Both relations are upward sloping, where, for reasonable parameter values, we find that the current account balance relation is flatter than the portfolio balance relation:

$$\frac{\Omega}{[(1 - \alpha_E)\beta_B^* + \beta_{E^*}\alpha_B]B^*} > -\frac{r}{TD_e}. \qquad (18)$$

Condition (18) also ensures that the equilibrium of our dynamic system is saddle point stable.[5] BGS provide an intuitive interpretation. An increase in US net foreign debt has two effects on the current account balance: it increases net factor income payments, thus fueling the accumulation of foreign debt, but also leads, through the portfolio balance relation, to more depreciated exchange rates, thus improving the trade balance and slowing down the accumulation of foreign debt. Condition (17) says that the second effect dominates to yield saddle point stability. The initial steady state is found at the intersection of the two relations in Point A. It defines the exchange rate and net foreign debt position of the US as prevailing in equilibrium. Using (4-7), we find the associated relative equity prices, P and P^*, and wealth positions, W and W^* in equilibrium.

To demonstrate the operation of our model, we consider the impact of an increased taste of the US for foreign goods. This argument is often put forward as an explanation for the widening US current account deficit. Our model easily accommodates such an external shock and allows studying the dynamic response. We disturb the initial equilibrium through an unexpected and permanent change in the shift parameter, s, that, all else equal, worsens the US trade balance. How does the dynamic system respond to the external shock? While the portfolio balance equation remains unchanged in response to a change in s, the current account balance relation

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[5]The condition will become important in the appendix, when rational expectations and non-zero imperfect asset substitutabilty are introduced.

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Figure 2: Current account and portfolio balance relation
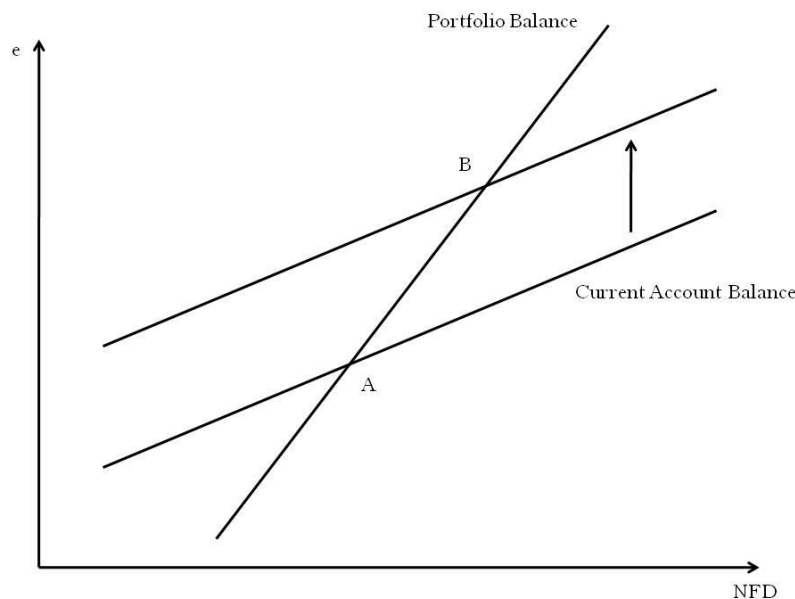
shifts upward in Figure 2. For a given level of net foreign debt and concomitant net factor income payments, the value of the US currency has to depreciate to compensate the increased taste for foreign goods, and thus to keep the current account in balance.

The transitory behavior is determined by our assumption of zero asset substitutability. We do not observe a jump at the initiation of the shock, but the beginning of a smooth convergence process along the portfolio balance curve towards the new long run equilibrium in Point B. On the transitory path, asset markets clear at all times and the exchange rate and relative equity prices move to ensure portfolio balance. The US current account, however, turns into deficit on impact and recovers only gradually over time as the US dollar loses value. Once the two economies reach the new equilibrium in Point B, the current account balance is restored and the accumulation of foreign debt comes to a halt. Since the US has accumulated additional foreign debt in the new equilibrium, the final value of the exchange rate is more depreciated to yield a trade balance that exactly offsets the net factor income payments on the now higher level of foreign debt. In Section 3, we analyze the consequences of a demand shock as displayed in Figure 2 in more detail.

3 Simulating the external adjustment

We distinguish between three scenarios when simulating the external adjustment process following the demand shock:

Scenario I considers the external adjustment process for varying rates of return on equity and bonds and compares it to a baseline scenario that assumes the same rates of return. The baseline scenario comes closest to the simulations of BGS since it does not discriminate between equity

and bond investment. Moreover, like BGS we disregard wealth effects in Scenario I.

Scenario II considers the external adjustment process for varying rates of return on equity and bonds with and without the wealth effect. The inclusion of the wealth effect shows that it has the potential to moderate the accumulation of foreign debt and exchange rate depreciation along the transitory path to a new equilibrium.

Scenario III capitalizes on the model's ability to recognize the structure of the international balance sheet. We compare the external adjustment process with a risk-seeking versus a conservative investment strategy and show that countries with a foreign portfolio that is tilted towards equity investments are better equipped to cope with external shocks. Scenario III is particularly relevant for the US and recognizes Stylized Fact 2.

In preparation for the simulation analysis, we first consider the data. More specifically, we will calibrate the model to capture the US external balance as it stands in 2006 and examine the joint dynamics of the current account, exchange rate and relative equity prices.

3.1   A first glance at the data

The information that we need to define the model parameters are summarized in Table 1. In 2006, the US had outstanding \$14.54 trillion of equity and \$27.29 trillion of bonds, whereas the RW had outstanding \$24.09 trillion of equity and \$42.09 trillion of bonds.

Table 1: Market capitalization and allocation in 2006 (in trillions of US-\$)

			Allocation	
Market Capitalization			US	RW
US	Equity	14.54	11.75	2.79
	Bonds	27.29	17.05	10.24
RW	Equity	24.09	4.33	19.76
	Bonds	42.09	5.19	36.90
Financial Wealth			38.32	69.69

Source: International Financial Statistics & BIS (2006)

These numbers highlight the outstanding position of US financial markets. They account for about 40 percent of worldwide equity and bond capitalization. The allocation of these assets reveals a considerable degree of portfolio home bias. US investors allocate 31 and 44 percent, respectively, of their financial wealth to home equity and bond markets, but only 11 and 14 percent, respectively, to international equity and bond markets. For foreign investors we find a similar degree of portfolio home bias with 28 and 53 percent, respectively, of financial wealth being invested in home equity and bond markets and only 4 and 15 percent, respectively, in US equity and bond markets. Next to portfolio home bias, the asset allocation of Table 1 confirms international balance sheet asymmetries discussed earlier (Figure 1b). The US invests

a relatively greater share of financial wealth in domestic and foreign equity, a total of 42 percent, in contrast to the rest of the world with a total of 32 percent. We take these percentages to define investors' asset preferences as in (3a-d). Finally, one can easily derive from Table 1, that the US net foreign debt position stood at $3.51 trillion in 2006, resulting from a $1.54 trillion long position in equity investments and a $5.05 trillion short position in bond investments.

Another important parameter is the trade balance responsiveness to exchange rate movements. The views on the responsiveness of the US trade balance to changes in the exchange rate differ widely and depend on a number of considerations. Goldberg and Tille (2006) state that for an exchange rate change to alter the trade balance, it must first affect the border prices of imported and exported goods, these prices need to be passed on to prices paid by consumers, and finally consumer must alter their consumption behavior - substitute away from imports if they have become relatively more expensive or increase import demand if they have become relatively cheap. Goldberg and Tille (2006) find an asymmetric effect of exchange rates across the US and its trading partners that they attribute to the special role of the US dollar as a vehicle currency. Exchange rate movements are mainly influencing the trade balance via exports, leaving US expenditure on imports, by and large, unchanged. Similarly, Gust and Sheets (2006) use simulation studies to argue that a 10 percent US dollar depreciation increases US real exports by about 9 percent. Together with a 12 percent export share of US GDP, this yields a 1 percent reduction of the US trade deficit relative to GDP. We adopt these numbers in our simulations and assume that every 10 percent depreciation in the exchange rate closes the US trade balance deficit by 1 percent of GDP. The chosen value is obviously important in assessing the necessary adjustments of the variables in absolute terms. However, our main interest concerns the relative adjustments in the three scenarios that we study now.

3.2 Scenario I - Simulations with varying rates of return

In this simulation study, we consider two sets of rates of return. First, we assume the same rate of return for all four assets, r_E, r_B, r_{E^*} and r_{B^*}, and set it equal to 3 percent. Obviously, the internal rate of return equals 3 percent as well and the current account balance relation in the steady state simplifies to (16). This is our baseline scenario and refers to the solid-line curves in Figure 3. As described above this scenario comes closest to the study of BGS. Next, we allow the rates of return to differ between bond and equity investments and set $r_B = r_{B^*}$ at 3 percent and $r_E = r_{E^*}$ at 6 percent, accordingly (dashed-line curves). In both simulations we ignore the wealth effect as a determinant of the trade balance. That is to say we observe asset price and exchange rate induced wealth transfers, but these transfers do not affect consumption, and hence import and export decisions in the US and RW.

Figure 3 shows the simulation results for an unexpected and permanent shock to the US trade balance that equals 1 percent of GDP. On impact the current account turns into deficit and triggers an equally-sized wealth transfer from the US to the RW. The wealth transfer pushes the four asset markets out of equilibrium and the earlier described mechanisms are set in motion. Portfolio home bias implies that the wealth transfer from the US to the rest of the world leads

Figure 3: Simulations with varying rates of return
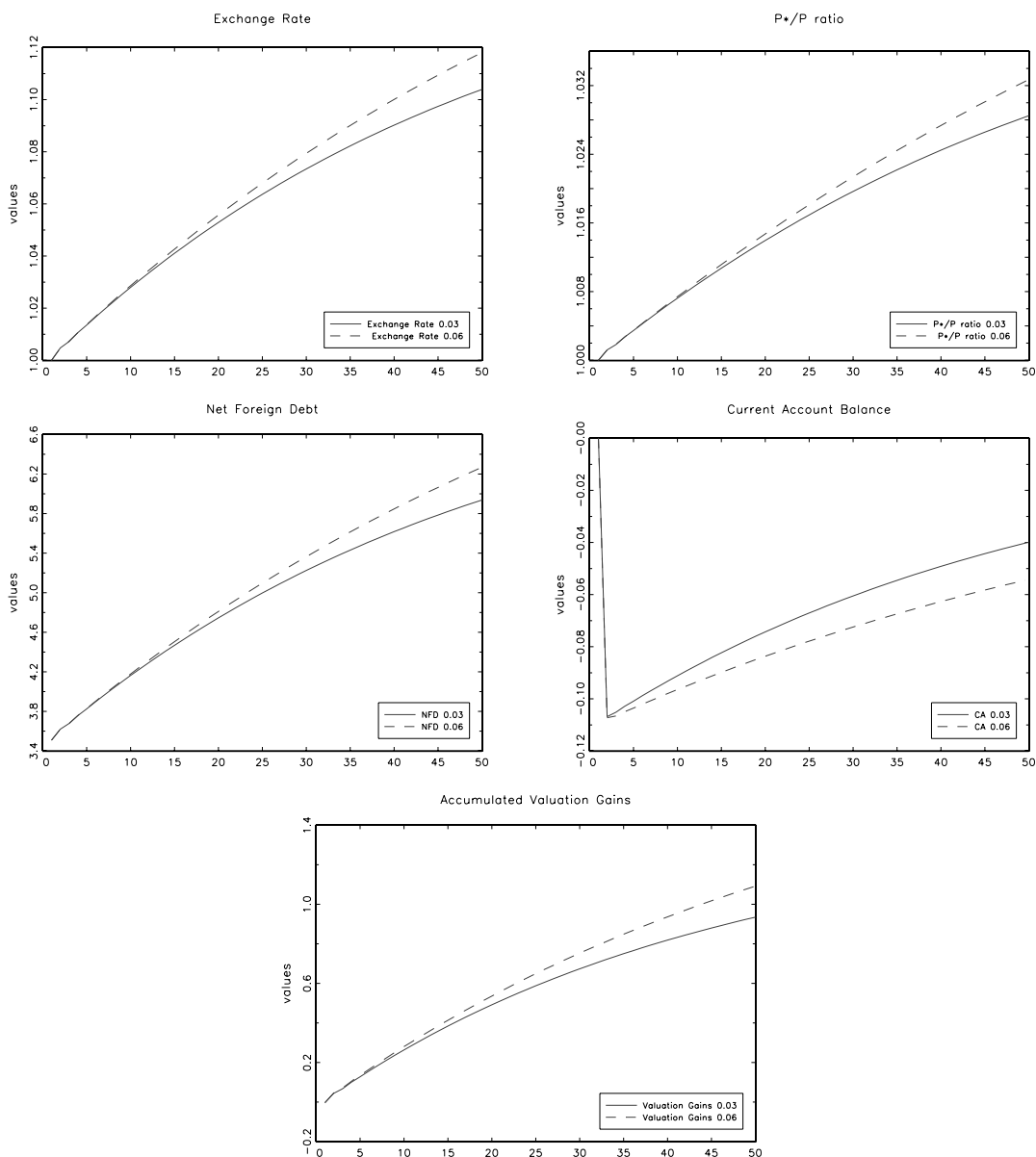
to a decrease in US demand for US assets that is less than offset by the concomitant increase in foreign demand for these assets. Excess supply of US assets results and the dollar exchange rate depreciates to restore equilibrium. A similar mechanism is at work for the relative equity prices, P and P^*. Given that foreign investors have a relatively lower preference for equity investment than their US counterparts, we see that P has to fall relative to P^* (or P^*/P to rise) in order to restore equilibrium in all asset markets. The new short run equilibrium set of relative prices, e, P and P^*, leads to changes in the US foreign debt position through revaluations of inherited stocks of foreign assets and liabilities and changes in the trade balance deficit - see (14). The change in net foreign debt feeds back into the asset markets and the process starts over again until the new steady state is eventually reached. As suggested by Figure 2, we see that all

variables converge smoothly to the new long run equilibrium. Moreover, the transitory path is stable for the chosen parameter values - condition (18) is fulfilled.

Our model produces results that are consistent with recent empirical findings. While the US is running current account deficits, we find stabilizing patterns of exchange rate and asset price movements. A depreciating exchange rate and a rising ratio of relative equity prices, P^*/P, imply that the US is generating valuation gains. That is, they earn more on their foreign assets than they pay out on their foreign liabilities. This is summarized in the last graph of Figure 3 which shows that these exchange rate and asset price induced valuation gains are sizable. Hypothetically, in the absence of valuation gains, the accumulation of US net foreign debt equals the sum of the current account deficits and would be greater by about one-third - a number that is broadly in line with the findings of Gourinchas and Rey (2007b).

Raising the rate of return on US and RW equity investments from 3 to 6 percent implies that the US faces higher net factor income payments on an increasing position of foreign equity liabilities. Consequently, the current account recovers more slowly from the initial shock, the wealth transfer from the US to the RW is amplified and exchange rates and relative equity prices respond in a more pronounced way. In terms of Figure 2, the increase in the rate of return on equity investments leads to an increase in the slope of the current account balance relation such that the same change in the shift parameter s implies a higher net foreign debt position and a more depreciated exchange rate in the new equilibrium.

3.3 Scenario II - Simulations including the wealth effect

In the second scenario, we compare two simulations. First, we copy the setting of scenario I with $r_B = r_{B^*}$ at 3 percent and $r_E = r_{E^*}$ at 6 percent disregarding wealth effects (solid-line curves), whereas in the second simulation wealth dynamics become an integral part of the dynamic system (dashed-line curves). Figure 4 shows both cases for the same shock to the US trade balance as before.

The quantitative specification of the wealth channel is not an easy task as empirical evidence is scarce. While both, Fratzscher et al. (2007) and Holinski and Vermeulen (2009) confirm the impact of financial household wealth on the current account, they need to rely on empirical proxies for financial household wealth in the absence of directly observable data. Usually data on stock market capitalization and asset prices are employed. Next to these measurement problems, the wealth effect may follow complex and forward-looking dynamics that are difficult to capture.

In our simulation study, we assume that one percent of the change in US and RW wealth is consumed on foreign goods and hence translates into the trade balance. For instance, a decrease in US wealth or increase in RW wealth improves the US trade balance since US consumers cut their expenditure on US imports and RW consumers increase their expenditure on US exports by one percent of the respective change in their wealth. We believe that the chosen value is in the more conservative range of plausible estimates for the wealth effect and follow Bernanke (2005) here.

**Figure 4:** Simulations including the wealth effect
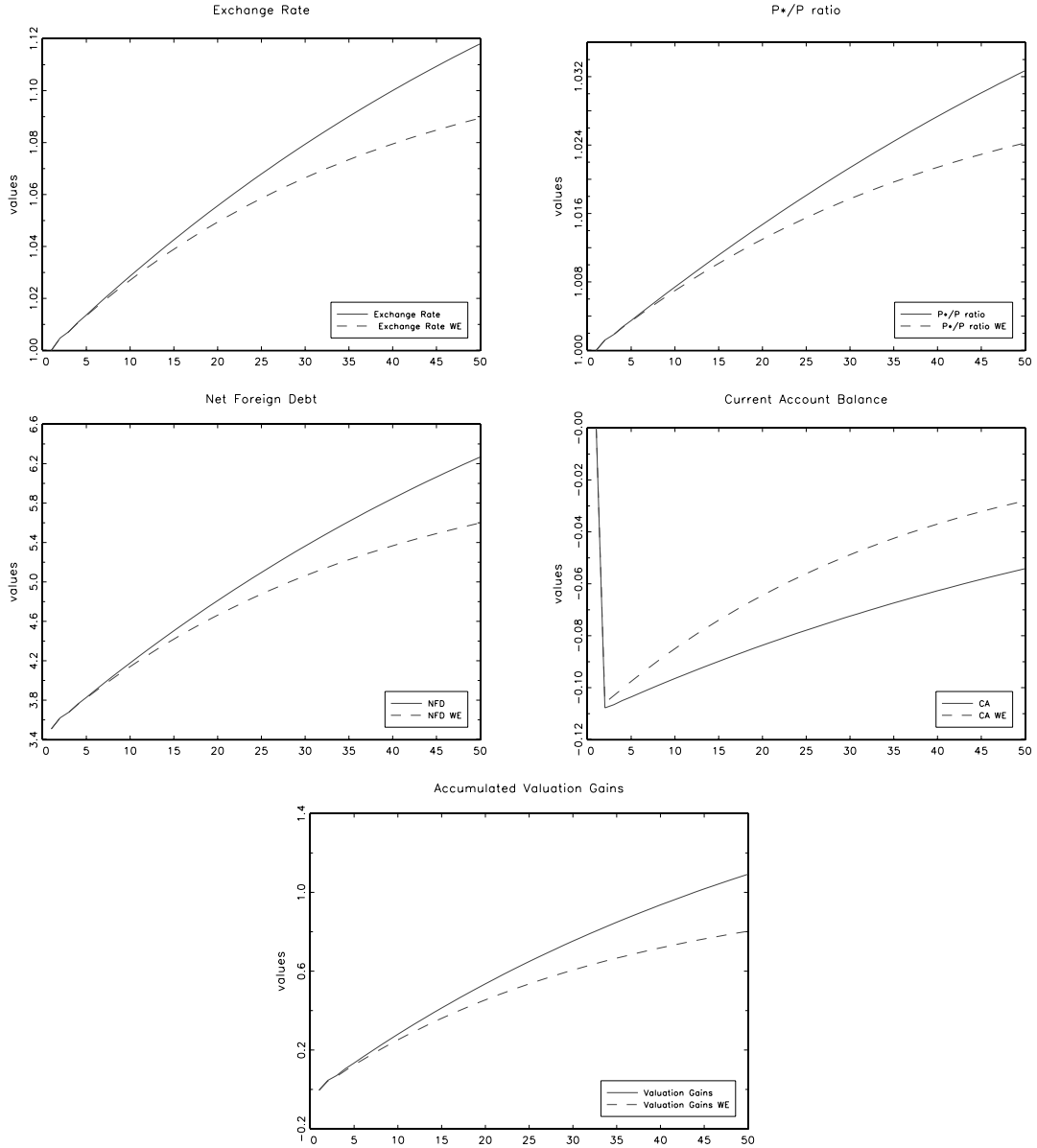
Before turning to the simulation results, we can already analyze the inclusion of the wealth effect within Figure 2. From (4) and (5) we see that US wealth is a negative and RW wealth a positive function of the exchange rate. Thus the inclusion of wealth dynamics opens an additional channel that assists the exchange rate in closing the US trade balance deficit. The current account balance relation becomes flatter in Figure 2 and, all else equal, less exchange rate depreciation and foreign debt accumulation can be expected following the initial shock. These are exactly the results that we find in Figure 4. The current account closes faster, the accumulation of US foreign debt is slowed down and less exchange rate and relative equity price adjustments are necessary to clear the asset markets. Although judging the magnitude of the wealth effect is obviously conditional on the chosen value for the responsiveness of the trade

balance to changes in US and RW wealth, our results indicate that it is a potent channel to reduce current account imbalances. Of course, another interpretation is admissible and deserves further investigation: the role of the wealth effect as the source, not the cure, of global imbalances.

3.4 Scenario III - Simulations changing the structure of the foreign portfolio

Our last simulation concerns the structure of the international balance sheet - the composition of foreign assets and liabilities. As noted by Rey (2005), we find that US foreign assets are tilted towards high-yielding equity, while the liability side is dominated by low-yielding treasury bonds. To study the consequences of this composition for the external adjustment process, we

Figure 5: Simulations changing the structure of the foreign portfolio
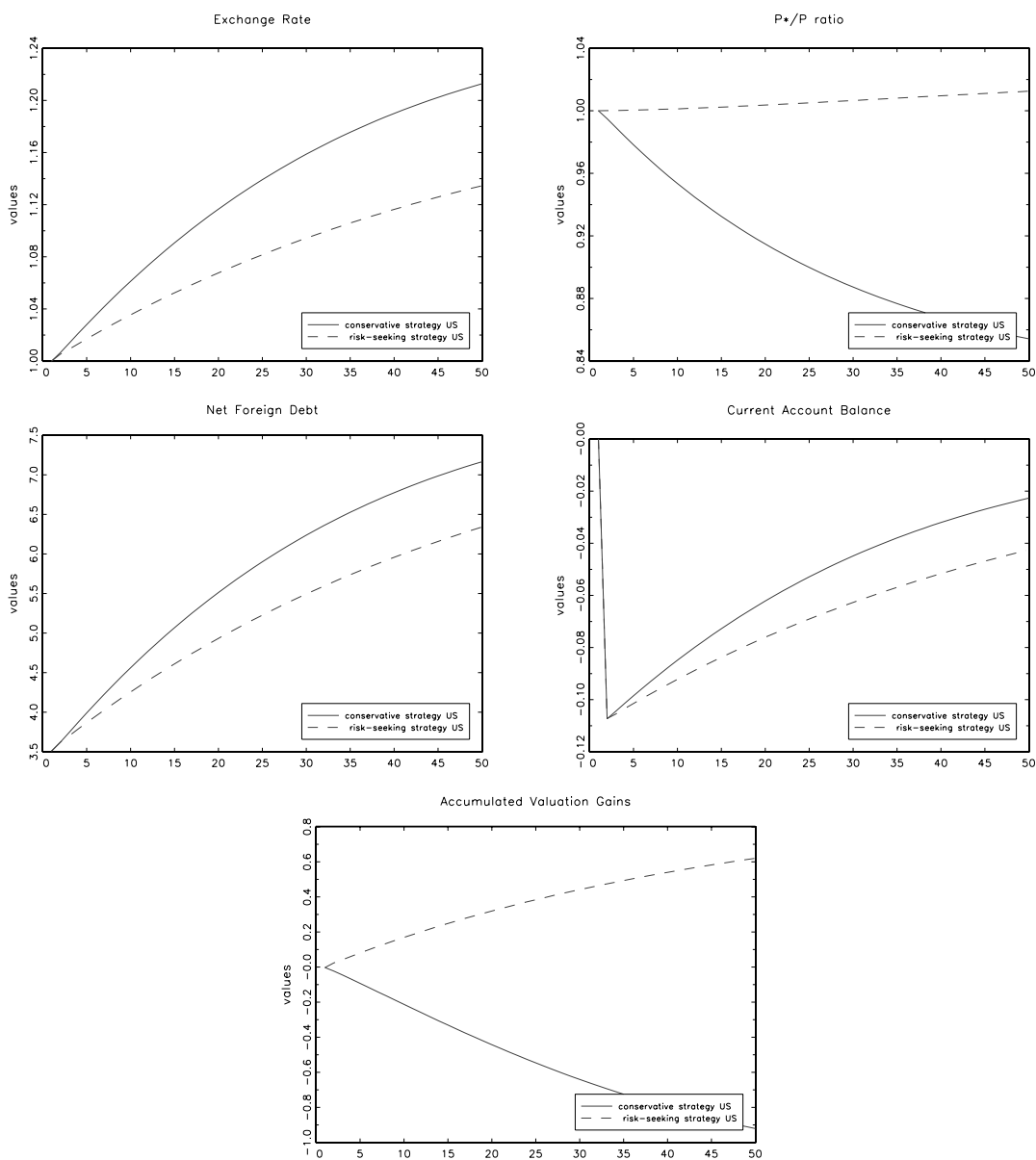
conduct a counterfactual experiment. As can be seen from Table 1, the US held a total of $9.52 trillion of foreign assets, matched by a total of $13.03 trillion of foreign liabilities, in 2006. Now consider the following two strategies. First, using a risk-seeking strategy the US holds 90 percent of its foreign assets in RW equity, while 90 percent of its foreign liabilities is invested in US bonds. Second, using a conservative strategy the US holds 90 percent of its foreign assets in RW bonds, while 90 percent of its foreign liabilities are held in US equity. These two polar cases are shown in Figure 5 as the dashed-line and solid-line curves, respectively. Note that we neither change the initial wealth positions of the US and the RW, nor the initial net foreign debt position of the US. What changes between both strategies and in comparison to the simulations in Figures 3 and 4 are the asset preferences of US and RW investors. We continue assuming that $r_B = r_{B*}$ at 3 percent and $r_E = r_{E*}$ at 6 percent and disregard the wealth effect for this study. The considered external shock stays the same - an exogenous increase in the US taste for foreign goods.

What does our model say about the role that the structure of the US foreign portfolio plays in the external adjustment process? From the simulations in Figure 5, we can see that the structure of the foreign portfolio is a decisive determinant. In the absence of its risk-seeking foreign investment behavior, the US would suffer from higher exchange rate depreciation and more foreign debt accumulation. The first graph in Figure 5 shows that the conservative investment strategy experiences almost twice as much depreciation of the exchange rate than the risk-seeking strategy. Also, the accumulation of net foreign debt sizably slows down under the risk-seeking strategy as can be seen in the third graph. The reasons are valuation gains stemming from the exchange rate and, partly, from relative equity prices. In fact, these valuation gains are strong enough to offset the higher current account deficits that emerge. Graph 5 provides a summary and reveals that the realized valuation gains of the US can be attributed to its investment strategy. The model's predictions are in line with recent empirical research (see for instance Gourinchas and Rey, 2007a,b).

4   Conclusion

It was our intention to get international portfolio-balance models back on the research agenda. This class of models provides useful guidance in thinking about the joint dynamics of external asset positions, exchange rates and asset prices, particularly nowadays with integrated capital markets. Building on the early contributions of Branson (1979), Henderson and Rogoff (1982) and Kouri (1983) and the more recent work of BGS, we have developed a portfolio-balance model that derives its relevance in light of stylized facts of international financial integration. In contrast to BGS, our model recognizes the tremendous increase in cross-border asset holdings, allows for the heterogeneous composition of these asset holdings and reproduces the disconnect of the current account and changes in the NIIP that has been found in the data. Calibrating the model to the external position of the US in 2006, we show the relevance of these stylized facts for the external adjustment process that follows a negative shock to the US trade balance.

In general, our model confirms that the valuation channels of exchange rate and relative asset price adjustment are stabilizing the external adjustment process and that these valuation gains are sizable. Moreover, we show that the structure of the international balance sheet is vital in explaining the exchange rate depreciation and foreign debt accumulation along the transitory path. We find that the US owes much to its risk-seeking investment strategy that not more foreign debt is accumulated and more exchange rate depreciation necessary. The same holds for the wealth effect. Under Scenario II, we have shown that the wealth effect opens up a potent channel for the exchange rate to close the current account deficit.

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Appendix A: Rational expectations and non-zero imperfect asset substitutability

The assumption that investors decide to allocate their wealth between different asset classes irrespective of relative return considerations can be replaced easily by that of imperfect, but non-zero asset substitutability. For the sake of completeness we consider this case here and incorporate the assumption similar to BGS. We show that the assumed degree of asset substitutability affects only the transitory dynamics of the model, but leaves the steady states unchanged. The steady state behavior is governed by the expenditure switching/reducing mechanism of the exchange rate.

To introduce rational expectations and non-zero imperfect asset substitutability we rewrite the α-shares for US investors and β-shares for foreign investors as functions of expected relative rates of return between all asset classes. Considering, for instance, the fraction of wealth that US and RW investors allocate to US equity, α_E and β_E, we first need to determine the expected relative return of US equity with respect to US bonds (R^e_{EB}), RW equity ($R^e_{EE^*}$) and RW bonds ($R^e_{EB^*}$). For simplicity, we disregard the steady state rates of return, r_E, r_B, r_{E^*} and r_{B^*}, and leave it with

$$R^e_{EB,t} = \frac{P^e}{P_t} - 1$$

$$R^e_{EB^*,t} = \frac{P^e}{P_t} \frac{e_t}{e^e} - 1$$

$$R^e_{EE^*,t} = \frac{P^e}{P_t} \frac{e_t}{e^e} \frac{P^*_t}{P^{*e}} - 1.$$

where the superscript e denotes the expected value of the corresponding variable as prevailing in the new steady state. If US equity is expected to generate a higher rate of return than the other asset classes, such that $R^e_{EB,t} > 0$, $R^e_{EB^*,t} > 0$ and $R^e_{EE^*,t} > 0$, both, US and foreign investors, want to reshuffle their portfolios. They allocate a greater fraction of their wealth to US equity according to

$$\alpha_{E,t}(R^e_{EB}, R^e_{EE^*}, R^e_{EB^*}) = \alpha^{SS}_E + \gamma(R^e_{EB,t} + R^e_{EE^*,t} + R^e_{EB^*,t})$$

$$\beta_{E,t}(R^e_{EB}, R^e_{EE^*}, R^e_{EB^*}) = \beta^{SS}_E + \gamma(R^e_{EB,t} + R^e_{EE^*,t} + R^e_{EB^*,t}).$$

α^{SS}_E and β^{SS}_E are the steady state allocations of wealth that can be derived from Table 1. These are the allocations in the initial and new steady states. Moreover we introduce the parameter γ that allows calibrating the degree of asset substitutability - the responsiveness of the wealth allocation to relative return differentials. The parameter γ is the same across shares[6].

The new portfolio and current account balance relations with rational expectations and imperfect, non-zero asset substitutability are depicted in Figure I. We consider the same external

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[6]All other wealth shares, $\alpha_{E^*,t}, \alpha_{B,t}, \alpha_{B^*,t}$ and $\beta_{E^*,t}, \beta_{B,t}, \beta_{B^*,t}$, are derived similarly such that investors reshuffle their portfolios over all asset classes based on expected relative return differentials.

Current Account and Portfolio Balance Relation with rational expectations
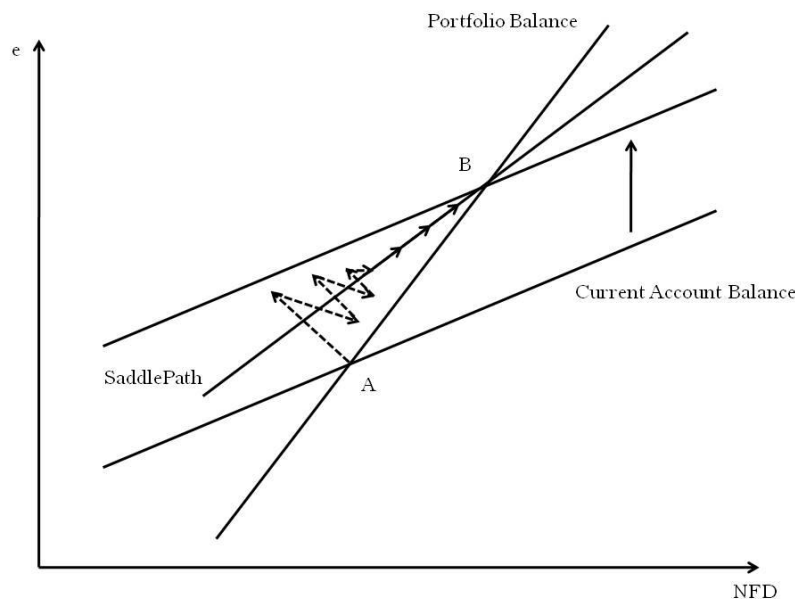
shock: an unexpected and permanent worsening of the US trade balance. The figure shows what has been discussed above. Introducing the assumption of imperfect asset substitutability does not alter the long-run behavior of our model - the external shock triggers the same shift of the current account balance relation and leads to the same long run equilibrium in Point B. What changes however is the transitory path to the new equilibrium. Instead of a continuous and gradual movement along the portfolio balance curve, we observe a jump from A towards the saddle path on impact and a movement along the saddle path towards the new equilibrium thereafter. The transitory dynamics are characterized by initial overshootings of the saddle path that fade out over time. The jump from A towards the saddle path is a consequence of the reshuffling of investors' portfolios. Following the disturbance, investors form their expectations within the model and thus expect a depreciating exchange rate until the new equilibrium in Point B is reached. The expected behavior of the exchange rate makes an investment in US assets less attractive relative to foreign assets. As a consequence, US and foreign investors want to adopt their wealth allocations accordingly and invest a greater share of their wealth in foreign assets. Excess supply of US assets results in and triggers an immediate exchange rate depreciation. At the same time, the depreciating exchange rate generates valuation gains as the US-dollar value of US foreign assets increases. The net foreign debt position shrinks.

For the simulation, we employ the same setting as in our baseline scenario in Figure 3 where the steady state rate of return is equal to 3 percent for all four assets and the wealth effect is disregarded. The degree of asset substitutability is set such that investors want to reshuffle approximately 5 percent of total wealth on impact. The simulation results are shown in Figure II and confirm the model's behavior that has been depicted in Figure I. Once the initial overshooting has faded, the system moves along the saddle path to the new equilibrium.

Figure II: Simulation - Rational expectations

Exchange Rate

Net Foreign Debt