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The US Dollar, Oil Prices and the US Current Account

by

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Abstract

The thesis examines how oil prices and asset stocks affect the US dollar. It also examines the role of different factors postulated in the literature to have caused recent US current account imbalances. In the first two chapters, I study the role of oil prices and the US government debt in determining US dollar movements. In Chapter One, I apply a theoretical portfolio balance model. In Chapter Two, I apply an empirical Error Correction Model. Chapter Two shows that the government debt and oil prices are significant short- and long-run determinants of US dollar movements. The findings of Chapter Two, that increases in the oil price and US government debt cause the US dollar to depreciate, are consistent with the predictions of Chapter One. The negative impact of an oil price increase on the US dollar is consistent, according to the portfolio balance models in Chapter One and in Krugman (1980), with a situation in which oil exporters tend to prefer non-US goods and assets. In Chapter Three, I find, using a Vector Autoregressive model, that the increase in the US government debt did not contribute to the widening of the US current account deficit. Also, in line with Killian et al. (2007), but in contrast to the "global savings glut" view, an oil-price increase improves the US current account balance. This occurs chiefly because a rise in the price of oil reduces US wealth, measured as the Standard and Poor equity index, which promotes US savings. China's increasing role in the world economy affects the US current account indirectly through the real oil price and the US government debt.

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Abbreviations

AIC	Akaike Information Criterion
ARDL	Autoregressive Distributed Lag
ARDL-SC	Autoregressive Distributed Lag-Schwartz Bayesian Criterion
BEA	Bureau of Economic Analysis
BIS	The Bank of International Settlements
Brent	British Price of Oil
CBOE	Chicago Board Options Exchange
CIPS	Coordinated Portfolio Investment Survey
COFER	Composition of Official Foreign Exchange Reserves
CPI	Consumer Price Index
DOLS	Dynamic Ordinary Least Squares
Dubai	United Arab Emirates Price of Oil
DV	Dummy Variable
EA	Euro Area
ECM	Error Correction Model
EMS	European Monetary System
FDI	Foreign Direct Investment
FEVD	Forecast Error Variance Decomposition
FFB	Federal Financing Bank
FFR	Federal Funds Rate
FPI	Foreign Portfolio Investment
G-5	Group of Five
G-7	Group of Seven
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
GNP	Gross National Product
ICAPM	International Capital Asset Pricing Model
IFS	International Financial Statistics
IMF	International Monetary Fund
IRF	Impulse Response functions
KI	Kilian Index
LIBOR	London Interbank Offered Rate
NFA	Net Foreign Assets
OECD	Organization for Economic Co-operation and Development
OIRF	Orthogonalized Impulse Response Functions

OLS	Ordinary Least Squares
OPEC	Organization of Petroleum Exporting Countries
PPI	Producer Price Index
PPP	Purchasing Power Parity
S&P 500 index	Standard and Poor's 500 index
SIC	Schwartz Information Criterion
SWFs	Sovereign Wealth Funds
TFP	Total Factor Productivity
TOT	Terms of Trade
UIP	Uncovered Interest Rate Parity
VAR	Vector Autoregressive
VECM	Vector Error Correction Model
VIX	Volatility Index
WTI	West Texas Intermediate

Introduction

The oil price increase since 2000 is remarkable as the price increased consistently, reaching US$145/barrel in July 2008 compared to a minimum of around US$10/barrel in 1998. Kilian (2009b) attributes the rise to the increase in global economic activity which resulted in the increase in the global demand for oil. This, in turn, may have caused oil exporters' revenues to increase beyond their consumption capacity, leading them to allocate their savings to foreign assets including US assets (Bernanke, 2007; Caballero, Farhi, and Gourinchas, 2008). At this time, as well, the US government relied on the issuance of government debt to finance the budget deficit. The increase in capital flows to the US put upward pressure on the US dollar while the increase in the supply of US assets due to domestic US borrowing put downward pressure on the US dollar (Elwell, 2008).

During 2002-2007, the real trade weighted exchange rate for the US dollar decreased by 29% (Elwell, 2008). The increase in the rate of depreciation raises concerns that a US dollar crisis could happen, causing an economic slow-down for the US economy (Krugman, 2007), as well as negative effects for non-US economies ranging from an economic slow-down to a recession (Elwell, 2008).

The objective of Chapter One is to theoretically study the impact of changes in oil prices and the supply of US assets on movements in the US dollar using portfolio balance analysis. Krugman's (1980) model is extended to allow for the interaction of the asset and oil markets in a model of exchange rate determination. This is carried out by employing a more general asset market and endogenizing oil imports. The extensions of the model serve in providing a more general model that captures the different possibilities for US dollar movements due to oil price changes in the short and long run, and allows for studying the impact of an exogenous shock to the supply of US assets.

The objective of Chapter Two is to use the portfolio balance model developed in Chapter One to study the role of the oil price and government debt as determinants of movements in the US dollar in an empirical dynamic framework. The error correction model (ECM) employed for the period 1986-2010 shows that the supply and demand components underlying oil price changes, and the ratio of the federal debt held by the public to gross domestic product (GDP) are significant determinants of US dollar movements. This result is robust when using either the price of oil or the components underlying oil price changes in the ECM. It is found that an increase in the price of oil results in a US dollar depreciation in the short and long run. This finding is in contrast to the previous empirical literature. However, according to the portfolio balance analysis of Krugman (1980), it is consistent with oil exporters having a higher preference for non-US goods and non-US assets during the sample period. As well, this finding of short-run US dollar depreciation is shown to be more likely, relative to Krugman (1980), in the generalized version of Krugman's (1980) model presented in Chapter One. The ECM also shows that US government debt has a downward impact on the US dollar which is in line with previous empirical and theoretical literature, and with the predictions of the model derived in Chapter One.

Bernanke (2007) and Caballero et al. (2008) have claimed that oil exporters' savings directed to the US have contributed to the increase in the US current account deficit, which is one of the features of the global imbalances witnessed during the 2000s. Chapter Three aims to provide a better understanding of the causes of the increase in the US current account deficit. Pinpointing the cause(s) of the problem and the potential interaction between such causes would help in deriving policies to avoid or at least dilute the negative effects of external imbalances. It would be of assistance for future research in deciding, for instance, on measures to influence the supply of global savings and the reliance of the US on foreign borrowing to finance the saving-investment gap and government debt, as well as the necessity of greater global coordination.

The objective of Chapter Three is to examine the factors behind the widening of the US current account deficit. I apply a vector autoregressive (VAR) model to jointly study the impact of China's role in the world economy and an increase in oil prices – which are possible contributing factors to the global savings glut – as well as the increase in global economic activity, US wealth, and US government debt on the US current account. The time period studied is 1986:1-2010:4. For robustness, the path of the US current account is simulated using the VAR estimates, and actual and hypothetical oil price series, to determine the magnitude of the oil-price effect on the US current account. In addition, I apply a VAR model to examine the additional hypothesis that the US current account is driven by shocks to the US-European productivity differential.

The main finding of Chapter Three is that the US government debt did not contribute to the widening of the US current account deficit. Chapter Three shows that an oil-price increase improves the US current account balance. This appears to contradict the "global savings glut" view that higher incomes of oil exporters were a major contributor to the US current account deficit. However, the VAR results indicate a higher oil price reduces the current account deficit by reducing US wealth through equity prices, which then raises US saving. Hence, a rise in the oil price leads to a rise in the current account balance, but may not be beneficial for the US economy overall.

Chapter 1: The Role of Oil Prices and the Supply of US Assets as Determinants of Movements in the US Dollar

Abstract

Krugman's (1980) analysis is extended to examine how changes in oil prices and the supply of US assets affect US dollar movements. Krugman (1980) shows that the higher the Organization of Petroleum Exporting Countries' (OPEC) preference for US assets and German goods, the more likely the US dollar will appreciate in the short run and depreciate in the long run due to an increase in the price of oil. Although Krugman (1980) includes in his model an asset market equilibrium condition, he does not study the impact of changes in the supply of US assets. The Krugman (1980) model is extended to allow for more interaction between the goods and asset markets by employing a more general asset model, and to allow the price elasticity of the demand for oil to vary across regions. Regarding the impact of oil price changes, the model shows that the asset market matters in determining the short-run impact, but not the long-run impact. The short-run impact is influenced by the extent of home bias for assets in the US and the rest of the world. It is also shown that a short-run US dollar appreciation is less likely in the case of the extended asset model relative to the Krugman (1980) model. In addition, the less price-elastic the US demand for oil, the less likely the US dollar is to appreciate in response to an oil-price increase. As for the impact of a positive exogenous shock to the supply of US assets, it is likely to have a downward effect on the US dollar in the short run.

Keywords: US dollar, oil prices, supply of US assets, portfolio balance model.

1 Introduction

Recently, movements in the US dollar and oil prices as well as the relationship between them have gained much attention. Interest in the effects of oil price changes on the economy has increased after oil prices reached US$145/barrel in July 2008 from a minimum of around US$10/barrel in 1998 (see Figures 1-1 and 1-2). Caballero et al. (2008) state that the increase in the oil price led to a surge in capital flows from oil exporting countries to the US and an increase in demand for "sound" and liquid US assets (Caballero et al., 2008, p.3). The low savings rate in the US also resulted in an inflow of foreign capital to the US, especially as the US government relied on debt to finance its budget deficit (Summers, 2004; Caballero et al., 2008; and Bernanke, 2005a; 2007). This is reflected in the ratio of the US federal debt held by the public to nominal GDP which reached approximately 63% by the end of 2010 after being around 45% at the end of 2008, around 36% at the end of 2006 and around 33% in the early 2000s (see Figure 1-3).[1]

The increase in capital flows to the US puts upward pressure on the US dollar. On the other hand, the increase in the supply of US assets due to domestic US borrowing puts downward pressure on the US dollar (Elwell, 2008). From the late 1990s until the end of 2001, the increase in oil prices was associated with US dollar appreciation. From 2002 until July 2008, oil prices continued to increase, but the US dollar started to depreciate and the rate of depreciation increased in 2004 (refer to Figure 1-4). During 2002-2007, the real trade weighted exchange rate for the US dollar decreased by 29% (Elwell, 2008). The annual rate of the drop in the US dollar was around 3%-4% for most of the period; moreover, it started to decrease at a rate of 10% in 2007 (Elwell, 2008).

The depreciation of the US dollar may be beneficial for the US as it may reduce the US trade deficit and net debt position, allowing the US to more easily finance its increasing liabilities (Blanchard et al., 2005). However, US dollar depreciation also

[1] The public debt is the sum of the debt held by the public and intra-governmental holdings. "The federal debt held by the public is federal debt held by individuals, corporations, state or local governments, foreign governments, and other entities outside the US government less the Federal Financing Bank securities" (http://www.treasurydirect.gov/govt/resources/faq/faq_publicdebt.htm).

causes foreign private investors and foreign Central Banks to incur capital losses on their US dollar denominated assets, resulting in a potential shift away from US assets (Blanchard et al., 2005). The increase in the rate of depreciation also raises concerns that a US dollar crisis could happen, causing an economic slow-down for the US economy (Krugman, 2007), as well as negative effects for non-US economies ranging from economic slow-down to a recession (Elwell, 2008).[2]

The objective of this chapter is to theoretically study the impact of changes in oil prices and the supply of US assets on movements in the US dollar using portfolio balance analysis. For that purpose, the Krugman (1980) model is extended. Krugman (1980) incorporates the influence of both the goods market and the asset market on the exchange rate to study the impact of an increase in the oil price on the US dollar in a three-region-model, where the three regions are the US, Germany and the Organization of Petroleum Exporting Countries (OPEC). Assuming OPEC prefers US assets and German goods, Krugman (1980) shows that the US dollar appreciates in the short run and depreciates in the long run due to an increase in the price of oil. Bénassy-Quéré et al. (2007) extend the Krugman (1980) model by incorporating China due to its important role in oil and exchange rate markets. They show theoretically that China reinforces short-run US dollar appreciation and long-run US dollar depreciation in the case of an increase in the oil price. They also explain that the depreciation of the US dollar causes the oil price to increase due to the high "sensitivity" of Chinese demand for oil (Bénassy-Quéré et al., 2007, p. 5804). That sensitivity is caused by two factors: China's oil-intensive production, and the yuan being pegged to the US dollar. The rationale for this result is that the depreciation of the US dollar has a positive impact on Chinese exports and economic activity, causing an increase in Chinese and, thereby, world demand for oil

[2] The increase in the rate of depreciation raises concerns regarding the occurrence of a US dollar crisis which would happen if the US dollar were to depreciate at an annual rate of 15%-20% (Elwell, 2008). The reason is that if the US dollar plummets, foreign investors would shift away from US dollar denominated assets. As a result, the interest rate increases and domestic investment is negatively affected. A worry is that the increase in US exports due to the depreciation of the US dollar takes place at a slow rate, while the shift away from the US dollar assets happens rapidly (Krugman, 2007).

and, accordingly, a rise in the real price of oil. Neither Krugman (1980) nor Bénassy-Quéré et al. (2007) study the impact of a change in the supply of US assets.

Empirically, the general finding of Amano and Van Norden (1998a and 1998b), Chaudhuri and Daniel (1998), Chen and Chen (2007), Coudert et al. (2008), and Bénassy-Quéré et al. (2007) is that there exists a stable positive long-run relationship between the price of oil and the US dollar over the post-Bretton Woods period in which an increase in the oil price results in US dollar appreciation. In addition, Bénassy-Quéré et al. (2007) examine the relationship between the two variables graphically for the period 1974 to 2004, and find that the US dollar depreciation associated with an increase in the price of oil from 2002 to 2004 is atypical and is consistent with the predictions of their theoretical model, but is in contrast to their empirical findings. As for the short-run impact, it is generally insignificant in these empirical studies.

The portfolio balance analyses of Branson et al. (1977) and Branson and Henderson (1985) show that an increase in the supply of domestic US assets, holding constant the supply of other assets – i.e., an exogenous increase – would generally result in a depreciation of the US dollar. Bernanke (2005b) explains that, if wealth affects consumption, the US dollar is expected to depreciate in the long run. Empirically, McMillin and Koray (1990), Cayen et al. (2010)[3], Kim and Roubini (2008), and Koray and McMillan (2007) find that an increase in government debt and deficits results in a US dollar depreciation.

The model built here is a three-region-model made up of the US, OPEC and the rest of the world (R). The Euro Area and Asia are included in the region R as they are important trade partners for OPEC. The Krugman (1980) assumption regarding the US (German) residents' holdings of German (US) assets is restrictive as it implies absolute home bias with regard to additions to wealth. This assumption is relaxed in this chapter to allow for a more general asset market which results in more interaction between the goods and asset markets. Hence, the first contribution of the current study is that it

[3] Cayen et al. (2010) is the only study that accounts for the price of oil.

combines two literatures and incorporates both oil prices and the supply of US assets in a model of exchange rate determination.

Krugman (1980) states that the results of his model will be affected if the price elasticity of demand for oil is different across regions; however, he does not study the short-run and long-run effects of oil price changes in this case. Bénassy-Quéré et al. (2007) extend the Krugman (1980) model by assuming that the income (activity) elasticity differs across countries; however, Bénassy-Quéré et al. (2007) assume the same price elasticity across countries. The second contribution of this chapter is that the model is further extended to examine the case in which the US and R price elasticities of the demand for oil are different.

Also, Krugman (1980) and Bénassy-Quéré et al. (2007) use a more restrictive asset market structure in studying the impact of oil price changes, and do not study the impact of a change in the supply of US assets on US dollar movements. The third contribution is that I examine both the short-run and long-run effects of an exogenous shock to the supply of US assets on US dollar movements.

The model derived here is different from Krugman (1980) and Bénassy-Quéré et al. (2007) in that it does not assume absolute home bias for additions to wealth, and the price elasticity of demand for oil differs in the US and R. The model shows that the asset market and home bias for US dollar and euro assets affect the short-run but not the long-run, impact of an oil-price increase on US dollar movements. As for the impact of an exogenous shock to the supply of US assets, in the short run, this shock has a downward effect on the US dollar. This finding is consistent with the previous theoretical and empirical literature on the impact of a change in the supply of assets on the exchange rate.

The rest of the chapter is organized as follows: The second section provides a literature review of portfolio balance analysis that serves to clarify the relationships between the variables of concern. In the third section, the model is given. The conditions derived in the third section, using the general asset model, and those derived by

Krugman (1980), are numerically assessed and compared to each other in the fourth section. The chapter is concluded in the fifth section.

2 Literature Review

This section provides an overview of the portfolio balance analysis literature and describes how this literature explains movements in the US dollar due to changes in the price of oil and foreign *demand* for US assets, as well as due to changes in the *supply* of US assets.

2.1 Portfolio Balance Analysis

The model developed in this chapter is an extension of the Krugman (1980) model. Bénassy-Quéré et al. (2007) also extend the Krugman (1980) model by incorporating China. However, these models study the impact of the change in the price of oil on the US dollar without accounting for the impact of a change in the supply of US assets. This chapter constructs a model that combines the insights of Krugman (1980) and Bénassy-Quéré et al. (2007) with a portfolio balance model of the type presented by Blanchard et al. (2005) that tackles the impact of a change in the demand for assets.

2.1.1 Oil Price Changes

Krugman (1980) develops a dynamic partial-equilibrium portfolio balance model to study the impact of an increase in the price of oil on movements in the US dollar. In his model, the US and Germany produce and export non-oil goods to each other and to OPEC, while OPEC produces and exports oil to the US and Germany. The model shows that the financial side dominates in the short run. The behaviour of the US dollar is dictated by the US share of world oil imports relative to the share of OPEC's portfolio held in US assets. In the long run, OPEC consumption increases to match the increase in oil revenues; hence, the real side dominates. The behaviour of the US dollar is dictated by the US share of world oil imports versus the US share of OPEC imports of non-oil goods.

Both the short- and long-run effects of an increase in the price of oil on the US dollar depend on OPEC preferences for US and German assets, and US and German goods. Based on the assumption that OPEC prefers US assets to German assets, such that the German share in OPEC oil exports exceeds the share of German-denominated assets in OPEC's portfolio, Krugman (1980) finds that the US dollar appreciates in the short run due to an increase in the price of oil. In the long run, if OPEC prefers German goods, such that the German share in OPEC imports exceeds its share in OPEC exports, the US dollar depreciates.

Bénassy-Quéré et al. (2007) modifies the Krugman (1980) model to account for the increasing role of China in the oil market as well as the foreign exchange market. The Bénassy-Quéré et al. (2007) model incorporates four entities: the US, Europe, OPEC and China. The exchange rate considered in their model is the US dollar-euro rate since it is assumed that OPEC and China peg their currencies to the US dollar. Bénassy-Quéré et al. (2007) show that, with China, an increase in the price of oil is likely to lead to a greater depreciation of the euro against the US dollar in the short run if the additional demand for euros by OPEC and China does not satisfy the additional demand for capital in Europe needed to offset the fall in the trade balance. China's presence makes euro depreciation more likely as long as China holds both US dollar and euro assets. The reason is that the increase in oil prices causes the Chinese trade balance to fall, decreasing the Chinese demand for euros. However, from a practical perspective this effect is not likely to be large because Chinese official reserves are "little diversified" (Bénassy-Quéré et al., 2007, p.5802). In the long run, the euro is expected to depreciate when the increase in Chinese demand for euro assets is less than the deterioration of the European trade balance that reflects Europe's demand for foreign assets (Bénassy-Quéré et al., 2007).

Given that the prediction of the long-run impact by the theoretical model depends on import and export shares, Bénassy-Quéré et al. (2007) calculate the shares of oil imports for the US, the Euro Area, China and Japan as well as their share of OPEC imports for the year 2003. They find that, in 2003, the difference between the Euro Area share in exports to OPEC (26%) and imports of oil from OPEC (25.5%) was small. This indicates that, in the absence of China, the euro/US dollar exchange rate is expected to change due to short-run changes in oil prices, but would return to a "baseline" in the long run (Bénassy-Quéré et al., 2007, p.5802). Their model predicts that if a considerable proportion of the Chinese trade surplus with OPEC is invested in euro assets, the euro will appreciate in the long run.

2.1.2 Changes in the Asset Market

Krugman (1980) and Bénassy-Quéré et al. (2007) incorporate the influence of asset and goods markets in the analysis of the impact of a change in the price of oil on the US dollar. Neither Krugman (1980) nor Bénassy-Quéré et al. (2007), however, study the impact of a change in the supply of or demand for US dollar assets on movements of the US dollar. Such effects are covered in the literature presented in this sub-section; however, this literature does not incorporate oil.

2.1.2.1 Dynamic Portfolio Model of the Demand for US Dollar Assets

Blanchard et al. (2005) employ a portfolio balance model, assuming imperfect substitutability between US and foreign assets, to study the behaviour of the US dollar. Their model incorporates a short run, where the exchange rate is determined mainly by asset market factors, and a long run, where goods market factors are most important for determining the impact of a shift in asset demand on the exchange rate.

Blanchard et al. (2005) show that an increase in the US demand for foreign goods results in a limited depreciation in the short run followed by an eventual steady depreciation. On the other hand, an increase in foreign demand for US assets would result initially in the appreciation of the US dollar. The appreciation of the US dollar would cause the deterioration of the US trade deficit and net debt position, resulting in the depreciation of the US dollar in the long run. The higher the rate of appreciation, the higher the ratio of the net debt position of the US to GDP, and the more the US dollar will depreciate in the long run. The less substitutable US and foreign assets – i.e., there is still a high preference for US dollar assets – the larger the initial appreciation and the larger the expected depreciation in the long run (Blanchard et al., 2005).

The depreciation of the US dollar is expected to have an upper bound because it is assumed that investors will continue to hold a fixed share of their portfolios in US dollar assets in spite of the "high negative expected return" (Blanchard et al., 2005, p.28). Blanchard et al. (2005) argue that investors will continue to opt for US dollar assets because of cross-country differences regarding financial development. However, according to Blanchard et al. (2005), a likely scenario is that investors as well as foreign central banks will diversify away from the US dollar; so the US share in foreign portfolios will decrease. Accordingly, it is more likely that the US dollar will depreciate in the short run. The larger the adverse shift, the more the short-run depreciation. The result is less debt accumulation and hence less long-run depreciation (Blanchard et al., 2005).

Blanchard et al. (2005) study how the extent to which foreign central banks shift away from US assets and the ending of the pegging of the Chinese currency to the US dollar would affect the exchange rate of the US dollar against the euro, the yen and the Chinese currency.[4] Blanchard et al. (2005) find that if the share of US assets in China's portfolio is zero, an increase in US net debt causes the US dollar to depreciate against the euro and the yen. If this share increases, there is a decrease in the rate of depreciation of the US dollar against the euro and the yen. If the share tends to one, the US dollar appreciates rather than depreciates against the euro and the yen. The reason is that a movement in wealth from the US to China represents a movement in wealth from US investors, who demand US dollar-, euro- and yen-denominated assets, to Chinese investors whose preference for US dollar-denominated assets is high. In other words, the movement of wealth to China results in an increase in the relative demand for US dollar-denominated assets, causing the US dollar to appreciate relative to the yen and the euro. If China's Central Bank shifts away from the US dollar, the relative demand for the euro

[4] China is different from the US, Europe and Japan as its currency is pegged to the US dollar and capital movements are restricted. Such restrictions limit Chinese residents from investing in foreign currency-denominated assets as well as restrict non-Chinese investors from purchasing Chinese assets. It is assumed that the Chinese central bank "acquires all dollars flowing into China: The wealth transfer from the US to the euro area and Japan is thus the US CA minus the fraction that is financed by the Chinese central bank" (Blanchard et al., 2005, p.37). "Pegging leads to a steady increase in US net debt and a steady increase in the foreign central bank's reserves, offsetting the steady decrease in private demand for US assets" (Blanchard et al., 2005, p.30).

and the yen to the US dollar increases, resulting in the depreciation of the US dollar against the euro and the yen.

2.1.2.2 Portfolio Balance Analysis of the Supply of Assets

This sub-section has, so far, covered the impact of a change in foreign demand for US assets. The rest of the sub-section provides an overview of the literature on the impact of a change in the supply of assets. Branson et al. (1977) provide an asset-market model of the short-run determinants of the US dollar/Deutschemark exchange rate. The focus is on the small country case where the world interest rate on "world traded assets" is "exogenously determined" (Branson et al., 1977, p.304). The model includes two interest-earning assets: a domestic (US) asset and a foreign (German) asset. As well, domestic residents hold money as a third asset. The domestic asset and money are not traded, but the foreign asset is. In other words, domestic money and assets cannot be "swapped" for foreign assets with the rest of the world; therefore, the only way to accumulate foreign assets is through "running a current account surplus over time" (Branson et al., 1977, p.304). The model first focuses on "portfolio balance of private investors" (Branson et al., 1977, p.311) and predicts, under static expectations, that an increase in the money supply through an expansionary open market operation that involves exchanging domestic money for domestic assets results in the depreciation of the US dollar. On the other hand, the effect of an increase in the stock of one asset, holding the others constant, depends on the type of asset. An increase in the money stock due to a budget deficit results in a US dollar depreciation. A decrease in the net foreign assets position of the domestic country is associated with a depreciation of its currency. However, a change in the supply of the domestic asset would have ambiguous results as it depends on the relative substitutability between the assets in the portfolio demand functions.[5]

[5] That is, the results depend on the relative response of domestic assets and domestic money to changes in the return on foreign assets.

Branson and Henderson (1985) build a portfolio balance model in which there are four assets: home money, foreign money, home assets and foreign assets. The model assumes that the assets are gross substitutes and there is no currency substitution. In addition to the open market operation cases tackled by Branson et al. (1977), Branson and Henderson (1985) study the impact of other intervention policies and account for the local asset preferences effect.

Branson and Henderson (1985) show that an increase in the domestic money supply in exchange for a decrease in the supply of the domestic asset – an open market operation – causes a decrease in the domestic interest rate. Such a decrease causes the domestic demand for domestic assets to decrease at a rate higher than the increase in the demand for money because such a decrease is associated with an increase in the demand for foreign assets. In addition, the decrease in interest rates results in a decrease in the foreign demand for domestic assets. Accordingly, the domestic currency is expected to depreciate.

Branson and Henderson (1985) also show that the trade of foreign assets for domestic money is similar to domestic open market operations in that the increase in the money supply is associated with a decrease in the home interest rate, and a depreciation of the home currency. The exchange of home assets for foreign assets does not involve a change in the money supply and hence the interest rates of the home and foreign countries do not change. Therefore, this is referred to as a sterilized intervention. For the case in which there is an increase in the quantity of the domestic asset and a decrease in the foreign asset, the home currency would depreciate to restore equilibrium. Finally, accounting for local asset preference, an increase in domestic residents' wealth causes an increase in the excess demand for domestic assets and a decrease in excess demand of foreign assets which are equal in amount, resulting in the same effect as that of the sterilized intervention case (Branson and Henderson, 1985).

Bernanke (2005b) focuses on the impact on the exchange rate of an exogenous increase in the value of US assets. Bernanke (2005b) states that the evolution of wealth is a crucial factor behind current account dynamics and US dollar movements. He claims that the drop in the US savings rate in the 2000s is due to the capital gains that US residents acquired in asset markets, which allowed them to feel wealthier. Higher consumption was financed by the “global supply of saving” directed mostly to the US as well as to France, Italy, Spain and the UK (Bernanke, 2005b, p.52). Bernanke (2005b) studies the impact of an exogenous increase in the value of US assets on the US dollar exchange rate. Bernanke (2005b) finds that when wealth raises consumption, a higher value of US assets has an impact analogous to an exogenous rise in US demand for foreign goods, and the US dollar depreciates by even more in the long run than in the short run. However, without this wealth effect on import demand, the currency deprecation is only temporary and the exchange rate returns to its initial value in the long run.

In summary, Krugman (1980) and Bénassy-Quéré et al. (2007) show that the US dollar would appreciate in the short run and depreciate in the long run due to an increase in the price of oil. The Krugman (1980) results depend on the assumptions regarding oil exporters’ preferences for US and non-US goods and assets. For instance, with the Krugman (1980) assumption that OPEC prefers German goods, so that the German share in OPEC imports is higher than the German share in oil imports, the US dollar depreciates in the long run. By adding China to Krugman’s (1980) model, Bénassy-Quéré et al. (2007) explain that, if China invests a considerable portion of its trade surplus with OPEC in euro assets rather than US dollar assets, the US dollar is more likely to depreciate in the long run. Blanchard et al. (2005) show that an increase in foreign demand for US assets results in a short-run appreciation and a long-run depreciation of the US dollar. The less the degree of substitutability between the US dollar- and euro-denominated assets – i.e., the higher the preference for US dollar assets – the higher the initial rate of appreciation and the eventual depreciation.

As for the supply of US assets, an increase in the supply of US assets due to open market operations and the exchange of domestic for foreign assets results in the depreciation of the domestic currency (Branson et al., 1977; and Branson and Henderson, 1985). As for an exogenous increase in the supply of domestic assets holding constant the supply of all other assets, which is the concern of the current research because it captures the impact of an increase in government debt, Branson et al. (1977) find ambiguous results which depend on the degree of asset substitutability, while Branson and Henderson (1985) find that the domestic currency depreciates. In addition, Bernanke (2005b) shows that with a wealth effect on consumption, the short-run effect of an increase in the value of US assets is US dollar depreciation and the US dollar is expected to depreciate in the long run as well.

The literature on the impact of a change in oil prices on the US dollar does not incorporate the impact of changes in the supply of US assets. The portfolio balance analyses of the impact of changes in the demand and supply of assets on the exchange rate do not incorporate the impact of changes in the price of oil. The theoretical model presented in this chapter incorporates both the price of oil and the supply of US assets in a model of exchange rate determination. Allowing for the interaction of the asset and goods markets, and endogenizing oil imports serve to improve the understanding of the economic conditions associated with short-run and long-run US dollar movements.

3 Portfolio Balance Model of Exchange Rate Determination

In what follows, the Krugman (1980) model is extended to study the US dollar movement in response to a change in the price of oil and to an exogenous shock to the supply of US assets. First, a model with a more general asset market is employed to study the impact of oil price changes on US dollar movements. Second, the model with the general asset market is extended to allow for endogenous oil imports. Third, the model is used to study the impact of an exogenous shock to the supply of US assets.

3.1 Setup of the Model

A three-region world consists of the US (US), OPEC (O), and the rest of the world (R). The Euro Area and Asia are major trading partners of the major oil exporters, and are viewed as being included in R (Ruiz and Vilarubia, 2007).[6]

The set-up of the model is in line with Krugman (1980) and Bénassy-Quéré et al. (2007) except that I relax two assumptions. First, residents of all three regions hold more US dollar and euro assets as their wealth increases. Krugman (1980) and Bénassy-Quéré et al. (2007), in contrast, assume that residents in each region hold constant the value of the assets issued by the other region. Second, the price elasticity of the demand for oil is allowed to deviate from zero, and can differ across regions. Although Krugman (1980) refers to this case, he did not study the short-run and long-run effects of oil-price change on the exchange rate under this less rigid assumption.

3.1.1 Goods Market

OPEC produces and exports oil to the US and R. The US and R produce non-oil products and export these to each other and to OPEC. The total of non-oil products imported by OPEC for consumption is denoted by C and measured in units of US goods; i.e., in real US dollars.

The real exchange rate (q) is the real R currency price of the US good. R's currency will be referred to as the euro.[7] An increase in q means the euro depreciates in value and the US dollar appreciates. It is assumed that the real price of oil (P_0) is exogenously given in units of US goods.[8] Hence, a real depreciation in the value of the

[6] In Bénassy-Quéré et al. (2007), the Krugman (1980) three-region world that consists of the US, Germany and OPEC is extended to become a four-region world that consists of the US, Europe, OPEC and China. The Bénassy-Quéré et al. (2007) objective is to study how the role of China, as an important player in the oil and exchange rate markets, influences the relationship between the price of oil and the US dollar. Bénassy-Quéré et al. (2007) explain that Europe can be extended to become any industrial country that follows a flexible exchange rate, and China can be extended to become any emerging economy that pegs its currency to the US dollar. The focus on a three-region model that consists of the US, OPEC and R in this chapter serves the objective of the current research, and provides a more tractable model.

[7] So $q = \frac{euro}{US\ dollar}\frac{US\ dollar\ price\ of\ US\ goods}{euro\ price\ of\ R\ goods}$.

[8] The price of oil is exogenously given in this model because (1) the oil price is determined in international markets, (2) the objective of Chapter One is to study the impact of oil price changes on the exchange rate, and not vice versa, (3) as per Krugman (1980, p.17), the alternative is to assume that OPEC pegs the oil price to a basket of dollars and marks. However, Krumgan (1980) notes that this change would not alter the results qualitatively, and (4), empirically, Amano and Van Norden (1998a and 1998b), Chaudhuri and Daniel (1998),

US dollar leaves the real price of oil unchanged, yet decreases the real price of oil in R. The relationship between the US and R price of oil is represented by the following equation where P_o^R is the real R price of oil:

$$P_o^R = qP_0. \quad (1)$$

The bilateral trade balance of R with the US is denoted by $T(q)$ and is measured in real US dollars. The trade accounts for the three regions are:

$$B_R = T(q) + \gamma(q)_R \cdot C - P_0 Oil_R, \quad (2)$$

$$B_{US} = -T(q) + \gamma(q)_{US} \cdot C - P_0 Oil_{US}, \quad (3)$$

$$B_O = P_0 Oil - C, \quad (4)$$

where B_i is the trade account for region i measured in units of US goods; $i = (US, O, R)$. The trade accounts of the three regions sum to zero; $B_{US} + B_R + B_O = 0$.

The share of OPEC expenditure on US products is $\gamma(q)_{US}$. The share of OPEC expenditure on R products is $\gamma(q)_R$; where $\gamma(q)_R = (1 - \gamma(q)_{US})$. Total OPEC consumption of non-oil products is:

$$\gamma(q)_R \cdot C + \gamma(q)_{US} \cdot C = C. \quad (5)$$

The R share of OPEC oil exports is $S_R = \frac{Oil_R}{Oil}$, where Oil_R is the volume of oil imports by R. The US share of OPEC oil exports is $S_{US} = \frac{Oil_{US}}{Oil} = 1 - S_R$, where Oil_{US} is the volume of oil imports by the US. OPEC total oil exports (Oil) are presented as follows:

$$S_{US} \cdot Oil + S_R \cdot Oil = Oil_{US} + Oil_R = Oil. \quad (6)$$

In Krugman (1980), both Oil_{US} and Oil_R are exogenously fixed and are independent of P_0 and q. I relax this assumption below.

A real depreciation of the euro against the US dollar causes R products to be cheaper. Hence, assuming the Marshall-Lerner conditions hold, R exports to the US and OPEC increase, and US exports to R and OPEC decrease: $\frac{\partial T(q)}{\partial q} > 0$; $\frac{\partial \gamma(q)_R}{\partial q} = -\frac{\partial \gamma(q)_{US}}{\partial q} > 0$.

Chen and Chen (2007), Coudert et al. (2008), and Bénassy-Quéré et al. (2007) find that the price of oil is weakly exogenous and is not Granger caused by the US dollar.

OPEC consumption adjusts with a lag; i.e., it does not change on impact. An increase in oil prices results in an increase in OPEC savings in the short run and, accordingly, in an increase in the demand for foreign assets. In the long run, OPEC consumption adjusts to the increase in oil revenues. This gradual adjustment in OPEC consumption to changes in export earnings is represented by:

$$\frac{dC}{C} = \mu(P_0 Oil - C); \quad 0 < \mu < 1 \quad \text{and } \frac{dC}{C} = 0 \text{ in the steady state.} \qquad 7$$

This assumption drives the dynamics of the model. Without this assumption, convergence to the long run would be immediate.

Unequal Price Elasticities of Demand for Oil

It is possible that the different regions exhibit different oil demand price elasticities. Cooper (2003) estimates the price elasticity of demand for oil for 23 countries, including the US, for the period 1971-2000. The US price elasticity of demand is around -0.061 in the short run and -0.453 in the long run. The average price elasticity for the 23 countries is -0.05 in the short run and -0.21 in the long run. Comparing the point estimates for individual countries shows that, in the short run, the US demand for oil is less elastic than that of Iceland, Korea, Spain, Ireland, Japan, France, and the UK. In the long run, the US demand becomes more elastic in the sense that it is only less elastic than that of France.

Ye et al. (2003) estimate the relative inventory level and the short-run price elasticity of demand for relative inventories for individual countries and country groups in the Organization for Economic Co-operation and Development (OECD) over the period January 1996 to June 2001.[9] Specifically, the results show that the US short-run price elasticity of demand for oil is less than that of Europe and Japan as the values of the elasticities were -0.0495, -0.0578, and -0.0587, respectively. However, all are very small.

In short, results from Cooper (2003) and Ye et al. (2003) imply that the US demand for oil was relatively more price-elastic over the period 1971-2000, and tends to

[9] Ye et al. (2003) study the deviation of the inventories in the petroleum market from the normal level, where the latter represents changes pertaining to a general trend and seasonal changes. In the short run, the supply and demand for petroleum products is less responsive to price movements than are inventories.

be relatively less price-elastic when focusing on the late 1990s and the 2000s. Moreover, Hamilton (2009, p.3) states that since the late 1990s, the US demand for petroleum has hardly exhibited a "downward deviation from the trend" despite the abnormal increase in the price of crude oil, suggesting a less price-elastic US demand for oil during this period.[10]

In Krugman (1980), it is assumed that the volumes of US and R oil imports are exogenously fixed; i.e. independent of changes in oil prices. In other words, the price elasticities of demand for oil in the US and R are assumed to be zero (perfectly inelastic). Krugman (1980) explains that modifying the model to allow price elasticities of demand for oil to deviate from zero and to differ across regions will alter the short-run and long-run effects of changes in oil prices. He introduces the equations for the marginal burden to R and the US due to an increase in oil prices. However, he does not derive the short- and long-run conditions for the impact of an oil price increase on the exchange rate when price elasticities of demand for oil are non-zero. Bénassy-Quéré et al. (2007) endogenize the oil demand of the US, Europe, and China in studying the impact of a change in the exchange rate on the oil price. They show oil demand may be positively affected by a fall in the US dollar, because US dollar depreciation raises the US's and China's exports, thereby raising world oil demand if China's oil demand rises sufficiently. They allow demand for oil to be affected by income where the income elasticity of demand for oil is more sensitive in the case of China. Although they allow the price elasticity of demand for oil to deviate from zero, they assume it is equal across regions.

In this chapter, the volume of oil imports is allowed to vary with changes in oil prices. The US demand for oil is a function of the real price of oil, and that of R is a function of the real oil price and the real exchange rate, q. The US and R demands for oil are assumed to be inelastic, but not perfectly inelastic, and are allowed to differ.

[10] "The price elasticity of petroleum demand has always been small, and it is hard to avoid any conclusion other than that it had become an even smaller number for the U.S. in the 2000s" (Hamilton, 2009, p.3).

Equilibrium in the market for oil implies that the summation of the volumes of R and US oil imports equals the volume of OPEC oil exports:

$$Oil = Oil_{US}(P_O) + Oil_R(P_O q) = Oil_{US}(P_O) + Oil_R(P_O^R). \quad 8$$

Hence, the OPEC trade balance is represented as follows:

$$B_O = P_O(Oil_{US}(P_O) + Oil_R(P_o q)) - C. \quad 9$$

The generalization of the model to allow the price elasticity of demand for oil to (1) deviate from zero and (2) to differ between the US and R makes the model more consistent with the empirical evidence.

3.1.2 The Asset Market

There are two assets in the model. The US supplies US dollar-denominated assets and R supplies euro-denominated assets, but OPEC does not supply assets. US, R and OPEC residents can hold both US dollar assets and euro assets. The total real US dollar assets supplied by the US in real US dollar terms is denoted by $\bar{D}$ and the total real euro assets supplied by R in real US dollar terms is denoted by $\frac{1}{q}\bar{E}$.

$$\bar{D} = D_{US} + D_R + D_O, \quad 10$$

where D_i is the US dollar assets in real US dollar terms held by $i\,; i = (US, R, O)$. Similarly,

$$\frac{1}{q}\bar{E} = \frac{1}{q}E_R + \frac{1}{q}E_{US} + \frac{1}{q}E_O, \quad 11$$

where $\frac{1}{q}E_i$ is the euro assets in real US dollar terms held by i.

Krugman (1980) assumes that US asset holders maintain a constant US dollar value of the euro-denominated assets they own, i.e., $\frac{E_{US}}{q}$ is constant, and R asset holders maintain a constant euro value of the US dollar denominated assets they own, i.e., qD_R is constant. In other words, R (US) residents purchase US dollar (euro) assets when the US dollar (euro) depreciates and sell US dollar (euro) assets when the US dollar (euro) appreciates. This is similar to assuming absolute home bias for additions to wealth since it means that an increase in US wealth causes no increase in US holdings of euro assets, and an increase in R asset holders' wealth causes no increase in their holdings of US dollar assets. This assumption is restrictive, as one would generally expect some increase in holdings of all assets when wealth increases. The model is extended so that US and R residents – along with OPEC residents – hold fixed shares of their wealth in US dollar and euro assets, as is usual in portfolio balance models, rather than a fixed value of the other country's assets. Hence, in the extended model, the total wealth (W) in real US dollars held by residents in each region is:

$$W_i = D_i + \frac{1}{q}E_i = (1 - \alpha_i)W_i + \alpha_i W_i \;; \qquad i = (US, R, O), \qquad 12$$

where $(1 - \alpha_i)$ is the share of US dollar assets in i's portfolio, and α_i is the share of euro assets in i's portfolio. So, $D_i = (1 - \alpha_i)W_i$ and $\frac{1}{q}E_i = \alpha_i W_i$.

3.1.3 Dynamic Behaviour

For the case in which there are no exogenous changes to asset stocks, the variation in i wealth is equal to the trade balance (B_i) and the valuation effect of euro-denominated assets. Hence,

$$dW_i = B_i - \alpha_i W_i \frac{dq}{q} \;; \qquad i = (US, R, O). \qquad 13$$

Since the share of euro assets in the OPEC portfolio is $\frac{E_O}{qW_O} = \frac{E_O/q}{W_O} = \alpha_O = constant$, the net change in the demand for euro assets by OPEC residents, measured in real US dollars, is:

$$\frac{dE_O}{q} = \alpha_O[B_O - \alpha_O W_O \frac{dq}{q}] + \alpha_O W_O \frac{dq}{q}. \qquad 14$$

The share of euro assets in the US portfolio is also assumed to be constant: $\frac{E_{US}}{qW_{US}} = \frac{E_{US}/q}{W_{US}} = \alpha_{US} = constant$. Therefore, the net flow of demand for euro assets by US residents in real US dollars is:

$$\frac{dE_{US}}{q} = \alpha_{US}\left[B_{US} - \alpha_{US} W_{US} \frac{dq}{q}\right] + \alpha_{US} W_{US} \frac{dq}{q}. \qquad 15$$

Finally, the assumption that the share of the US dollar asset in the R portfolio is a constant means $\frac{D_R}{W_R} = (1 - \alpha_R) = constant$. Therefore, the net flow of demand for US dollar assets by R residents is:

$$dD_R = (1 - \alpha_R)[B_R - \alpha_R W_R \frac{dq}{q}]. \qquad 16$$

Substituting equations (14), (15), and (16) into the R Capital Account (KA) equation:

$$KA_R = \frac{1}{q} dE_{US} + \frac{1}{q} dE_O - dD_R, \qquad 17$$

yields equation (18):

$$KA_R = \alpha_{US}[B_{US} - \alpha_{US} W_{US} \frac{dq}{q}] + \alpha_{US} W_{US} \frac{dq}{q} + \alpha_O [B_O - \alpha_O W_O \frac{dq}{q}] + \alpha_O W_O \frac{dq}{q} - (1 - \alpha_R)[B_R - \alpha_R W_R \frac{dq}{q}]. \qquad 18$$

As $KA_R + B_R = 0$,

$$KA_R + B_R = \alpha_{US} B_{US} + \alpha_O B_O + \alpha_R B_R + \frac{dq}{q}(\alpha_{US}(1 - \alpha_{US}) W_{US} + \alpha_O (1 - \alpha_O) W_O + \alpha_R (1 - \alpha_R) W_R) = 0 . \qquad 19$$

Re-arranging equation (19), the equation for the rate of change in the exchange rate is:

$$\frac{dq}{q} = - \frac{(\alpha_{US} B_{US} + \alpha_O B_O + \alpha_R B_R)}{[\alpha_{US}(1-\alpha_{US}) W_{US} + \alpha_O (1-\alpha_O) W_O + \alpha_R (1-\alpha_R) W_R]} = - \frac{(\alpha_{US} B_{US} + \alpha_O B_O + \alpha_R B_R)}{\left[(1-\alpha_{US}) \frac{E_{US}}{q} + \alpha_O (1-\alpha_O) W_O + \alpha_R D_R\right]}, \qquad 20$$

where $\frac{E_{US}}{q} = \alpha_{US} W_{US}$ and $D_R = (1 - \alpha_R) W_R$.

Equation (20) shows that, when the US and R are allowed to hold more US dollar and euro assets as their wealth increases, and hence interaction between the asset and oil markets is allowed, the rate of change in the exchange rate is influenced by the three regions' trade balances and asset holdings. Equation (20) collapses to the Krugman (1980) equation for the rate of change in the exchange rate if $\alpha_R = 1$ and $\alpha_{US} = 0$, which is in line with the restrictive Krugman (1980) assumption regarding R and US residents' asset demand functions. The restricted Krugman (1980) version of the equation for the rate of change in the exchange rate is:

$$\frac{dq}{q} = - \frac{(\alpha_O B_O + B_R)}{\left[\frac{E_{US}}{q} + \alpha_O (1-\alpha_O) W_O + D_R\right]}. \qquad 20'$$

3.2 Portfolio Balance Model of the Impact of Oil Price Changes on the US Dollar with an Extended Asset Market

In this sub-section, I examine the effect of a rise in oil prices when the more general asset market is employed (the case of equation (20)). In other words, US and R residents, as well as OPEC residents, hold more US dollar and euro assets as their wealth increases. The US and R oil imports are considered to be exogenously fixed in this sub-section.

3.2.1 The Short Run Impact of a Change in the Price of Oil

Since OPEC consumption adjusts with a lag, the impact of an oil price change differs in the short run and the long run. In the short run, C is constant, resulting in a one-for-one increase in OPEC savings due to an increase in the price of oil. To be consistent with the analysis in Krugman (1980) and Bénassy-Quéré et al. (2007), static expectations are assumed.[11] Since OPEC consumption – and, hence, imports – only change gradually with a rise in the oil price, under the static expectations assumption[12], the exchange rate, q, does not change on impact, $\frac{dq}{dP_0} = 0$, but the rate of change of the exchange rate, $\frac{dq}{q}$, does change on impact. Hence, following Krugman (1980), the oil price short-run effect is the effect on the rate of change of the exchange rate, $\frac{d\left(\frac{dq}{q}\right)}{dP_0}$. In the long run, the level of q changes, so one then looks at $\frac{dq}{dP_0}$.

[11] Assuming that expectations are static, rather than rational, may not be unreasonable in light of Krugman's (2007) explanation that in the 2000s, investors in US dollar assets were not accounting for the eventual depreciation of the US dollar required to curtail the increasing US external debt.

[12] Under static expectations, the forecast of the future value of the exchange rate is the current value. In this case, the model always adjusts to a stable equilibrium. Under adaptive expectations, to achieve a stable equilibrium, the exchange rate and the rate of change in the exchange rate jump discretely in response to new information. Hence, the paths of the exchange rate and the rate of change of the exchange rate are indeterminate. Under rational expectations, characterized by saddle path equilibrium, the existence of an equilibrium is based on the assumption that the rate of change in the exchange rate is assigned an initial value and that speculators' behaviour causes this rate of change to continuously jump to stay on the stable path (Masson, 1981). Krugman (1980) explains that under rational expectations the path of the exchange rate will change as the distinction blurs between the short-run and long-run effects. Under rational expectations, the factors influencing the long-run impact will start to have an impact earlier than they will under static expectations (Krugman, 1980). Krugman (1980) provides two scenarios to compare results under static and rational expectations. The first scenario under rational expectations involves the financial factors initially affecting the US dollar movements as was the case under static expectations, but for a shorter period, as the real factors start having an impact earlier than in the case of static expectations due to rational expectations. The second scenario involves rational expectations causing the real factors to fully affect US dollar movements from the beginning. Carrying out the analysis in the current research under static expectations is useful for deriving a benchmark case to which models derived under other forms of expectations can be compared.

Using equations (2), (3), (4) and (20), and taking into account that the exchange rate does not change on impact, the equation for the short-run impact of a change in oil price on the rate of change of the exchange rate is:

$$\frac{d\left(\frac{dq}{q}\right)}{dP_O} = \frac{[(\alpha_R - \alpha_{US})S_R - (\alpha_O - \alpha_{US})]Oil}{[\alpha_{US}(1-\alpha_{US})W_{US} + \alpha_O(1-\alpha_O)W_O + \alpha_R(1-\alpha_R)W_R]} . \qquad 21$$

In equation (21), the denominator is positive since it depends on the wealth of the US, R and OPEC; hence the direction of US dollar movements depends on the numerator. Re-arranging the numerator, the direction of movement depends on the value of $(\alpha_R S_R + \alpha_{US} S_{US})\ versus\ (\alpha_O)$, since $S_{US} = 1 - S_R$.

In the short run, a rise in oil prices results in an increase in OPEC demand for foreign assets. As a result, the US and R capital accounts improve. On the other hand, OPEC consumption – and hence US and R exports to OPEC – does not change on impact. As well, an increase in oil prices causes the value of oil imports to increase. Consequently, the US and R trade balances deteriorate. The US and R finance the fall in their trade balances by selling assets.

Accordingly, $(\alpha_R S_R + \alpha_{US} S_{US})$ reflects the increase in capital flows required by R and, hence, the increase in the supply of euro assets – at given shares of oil imports – to offset the deterioration in the R trade balance due to the rise in the oil price. If the parameter α_O, which captures OPEC's demand for euro assets, is high, such that $(\alpha_R S_R + \alpha_{US} S_{US} < \alpha_O)$, the US dollar depreciates against the euro in the short run. And, if $(\alpha_R S_R + \alpha_{US} S_{US} > \alpha_O)$, the US dollar appreciates against the euro. In other words, the euro will appreciate (depreciate) against the US dollar if the demand for euro assets by OPEC is more (less) than needed to offset the deterioration in the R trade balance.

In Krugman (1980), the assumption on US and R wealth holdings is equivalent to assuming $\alpha_R = 1\ and\ \alpha_{US} = 0$. With these restrictions, equation (21) becomes the same as that in Krugman (1980), which is represented by equation (21'):

$$\frac{\partial \frac{dq}{q}}{\partial P_O} = \frac{[S_R - \alpha_O]Oil}{\left[\frac{E_{US}}{q} + \alpha_O(1-\alpha_O)W_O + D_R\right]} . \qquad 21'$$

Equation (21') shows that the direction of movement of the exchange rate in the short run due to a change in the price of oil depends on the sign of $[S_R - \alpha_o]$. If the euro asset share in OPEC's portfolio is higher than the R share in OPEC exports, $[S_R < \alpha_o]$, the flow of capital from OPEC to R is high enough to offset the fall in the R trade balance due to the increase in the price of oil. In such a case, $\frac{d\left(\frac{dq}{q}\right)}{dP_0} < 0$, indicating a short-run depreciation of the US dollar. The reason is that the increase in the demand for euro assets means there is a shift away from US assets, which causes the euro to appreciate against the US dollar. On the other hand, if OPEC has a strong preference for US assets, so α_o is smaller, the numerator is more likely to be positive, $[S_R > \alpha_o]$, as a greater portion of OPEC capital is purchasing US assets instead of R assets. As a result, the smaller the value of α_o, the more likely the US dollar will appreciate in the short run, $\frac{d\left(\frac{dq}{q}\right)}{dP_0} > 0$.

In order to compare equations (21) and (21'), the numerator of equation (21) is re-arranged to become $(((\alpha_R - \alpha_{US})S_R + \alpha_{US}) - \alpha_O)$. The comparison shows that home bias for US dollar and euro assets matters to the condition derived in this chapter and not to the condition derived by Krugman (1980). As long as the home bias assumption holds, $(\alpha_R > \alpha_{US})$, the direction of US dollar movements is affected by S_R and α_O in the two conditions. However, the magnitude of the change is different in the two equations as it is influenced in the condition derived in this chapter by the share of euro assets in the US and R portfolios. If the home bias assumption does not hold, such that $(\alpha_R = \alpha_{US})$ or, $(\alpha_R < \alpha_{US})$, the results become ambiguous.[13] It is important to take into account the extent of home bias as it shows the role of the wealth transfer effect in explaining movements in the exchange rate. Note that US home bias tends to be higher than that of R, hence α_{US} tends to be small and $(\alpha_R > \alpha_{US})$ will hold. This is consistent with the

[13] If $\alpha_R = \alpha_{US}$, the outcome of equation (21) involves comparing α_{US} to α_O. If $\alpha_R < \alpha_{US}$, $(\alpha_R - \alpha_{US})S_R$ is a negative term, and the outcome of equation (21) involves comparing α_{US} to α_O + $(\alpha_R - \alpha_{US})S_R$.

Blanchard et al. (2005) computations regarding the US, Europe and the rest of the world's portfolio shares which are discussed in more details in Section 4.

It is also important to examine whether the effect of an oil price increase is more or less likely to lead to US dollar depreciation with the more general asset model relative to the Krugman (1980) model. The condition for a short-run US dollar appreciation in the more general model derived here is $(\alpha_R S_R + \alpha_{US} S_{US} > \alpha_O)$, while in Krugman (1980) it is $(S_R > \alpha_o)$. According to Krugman's (1980) model, a rise in the price of oil raises the supply of euros from R by S_R.[14] The demand for euros rises with OPEC's demand, α_O. In the more general asset model, a rise in the price of oil raises the supply of euros by $(\alpha_R S_R + \alpha_{US} S_{US})$. That is, the supply of euro assets, in the case of the more general asset model, rises with the share of R in oil demand, S_R, multiplied by the share of R's asset holdings in euros, α_R, plus the share of the US in oil demand, S_{US}, multiplied by the share of US assets held in euros, α_{US}.

There are three cases in which the new condition for US dollar appreciation, $(\alpha_R S_R + \alpha_{US} S_{US} > \alpha_O)$, is less likely to be satisfied than the Krugman (1980) condition, $(S_R > \alpha_o)$. A first case would occur if R residents held some US dollar assets, but US residents held no euro assets, so $\alpha_R \epsilon (0,1)$ and $\alpha_{US} = 0$.[15] Hence, the new condition would collapse to $(\alpha_R S_R > \alpha_O)$ where $\alpha_R S_R < S_R$. While this case is not realistic, there is some evidence that the US has very strong home bias, and a stronger home bias than foreign residents. For example, Blanchard et al. (2005, p. 18) collect rough data to suggest $(1 - \alpha_{US})$ was about 0.77 and α_R was about 0.71 in 2003, so the US has a greater home bias than Europe and Japan, which they combine to represent the rest of the world. If the rest of Asia is also included, there is likely to be an even greater bias toward US assets. This US dollar bias is not surprising, given that the US dollar is the main world reserve currency, and the currency most widely used in trade.

[14] An oil price increase causes R to increase the supply of euro assets to offset its trade balance deterioration due to the oil price increase.

[15] Note that in Krugman (1980), $\alpha_R = 1$ and $\alpha_{US} = 0$ whereas here $\alpha_R \epsilon (0,1)$ and $\alpha_{US} = 0$.

In a second case, assume that $\alpha_{US} \epsilon (0,1)$, but α_{US} is small. If both regions have similar shares of oil imports, so $S_R = S_{US} = 0.5$, as long as R residents hold a greater share of US assets than US residents hold of euro assets, $(1 - \alpha_R) > \alpha_{US}$, so $(\alpha_R + \alpha_{US}) < 1$, then $(\alpha_R S_R + \alpha_{US} S_{US}) < S_R$. In such a case, the US dollar is less likely to appreciate relative to Krugman's (1980) case.

Finally, even if the US imports a smaller share of oil than R, so $S_{US} < S_R$, if the US holds few foreign assets, so α_{US} is quite small, then a US dollar appreciation is less likely relative to Krugman's (1980) case. This is easier to see if I re-arrange the condition for a US dollar appreciation to note that it implies that the US dollar is less likely to appreciate, relative to Krugman's (1980) case, if $\frac{S_{US}}{S_R} < \frac{(1-\alpha_R)}{\alpha_{US}}$.[16]

For the discussion of the economic factors and stylized facts driving these results, refer to Section 4, below.

3.2.2 The Long-Run Impact of a Change in Oil Prices

In the long run, the OPEC trade balance is zero in equilibrium. So, an oil price increase which raises the value of OPEC exports, $P_0 Oil,$ leads to an equal increase in imports and consumption C. Therefore, $P_0 Oil = C$, and hence $B_0 = 0$. This means that an increase in the oil price leads to a one-for-one increase in OPEC imports. So, in the long run,

$$\frac{dC}{dP_0} = Oil. \qquad 22$$

In the long run, the equilibrium rate of change of the exchange rate is zero, so $\frac{dq}{q} = 0$. Further, following Krugman (1980), $B_{US} = B_R = B_O = 0$. To derive the long-run condition, substitute equation (4) into equation (2), and differentiate the outcome with respect to P_O. The equation for the long-run impact of a change in the oil price is:

$$\frac{dq}{dP_O} = \frac{[S_R - \gamma(q)_R]Oil}{\left[\frac{\partial T(q)}{\partial q} + \frac{\partial \gamma(q)_R}{\partial q} C\right]} . \qquad 23$$

[16] Re-arranging $(\alpha_R S_R + \alpha_{US} S_{US}) < S_R$, $\alpha_{US} S_{US} < S_R(1 - \alpha_R)$. Then, $\frac{S_{US}}{S_R} < \frac{(1-\alpha_R)}{\alpha_{US}}$.

According to equation (23), if OPEC prefers US goods, such that R's share of OPEC exports exceeds its share of OPEC imports, so $S_R > \gamma(q)_R$, $\frac{dq}{dP_O} > 0$, indicating that the US dollar would appreciate. On the other hand, if OPEC has a strong preference for R goods such that the R's share of OPEC imports exceeds its share of OPEC exports ($S_R < \gamma(q)_R$), then $\frac{dq}{dP_O} < 0$ and the US dollar would depreciate. Note that the long run condition in equation (23) is the same as that in Krugman (1980).

Equation (23) shows that the long-run impact is influenced by the US share of OPEC imports and exports. The condition does not include a parameter for the share of asset holdings in i's portfolio, where $i = (US, O, R)$. This confirms that the asset market does not have an impact in the long run, even when a more general asset market specification is employed.

3.3 Portfolio Balance Model of the Impact of Oil Price Changes on the US Dollar with an Extended Asset Market and Endogenous Oil Imports

In this sub-section, the model in the previous sub-section is extended to allow for endogenous oil imports. So, in this sub-section, US oil imports are a function of the real price of oil, P_O, and R oil imports are a function of the real price of oil, P_O, and the real exchange rate, q. Therefore,

$$Oil_{US} = Oil_{US}(P_O), \qquad Oil'_{US}(P_O) < 0, \qquad \text{24a}$$

$$Oil_R = Oil_R(qP_O), \qquad Oil'_R(qP_O) < 0. \qquad \text{24b}$$

3.3.1 The Short-Run Impact of a Change in Oil Prices

Using equations (2), (3), (4), (8), (20), (24a) and (24b), and taking into account that the exchange rate does not change on impact, the equation for the short-run impact of a change in oil prices on the rate of change of the exchange rate is:

$$\frac{\partial \frac{dq}{q}}{\partial P_O} = \frac{[(\alpha_{US}\tilde{S}_{US}+\alpha_R\tilde{S}_R)-\alpha_O]\{Oil_{US}[1-\varepsilon_{US}]+Oil_R[1-\varepsilon_R]\}}{[\alpha_{US}(1-\alpha_{US})W_{US}+\alpha_O(1-\alpha_O)W_O+\alpha_R(1-\alpha_R)W_R]}. \qquad 25$$

The parameter ε_i is the price elasticity of demand for oil, $\varepsilon_i = -\frac{\partial Oil_i}{\partial P_O^i}\frac{P_O^i}{Oil_i} > 0$; $i = (R, US)$ and $P_O^{US} = P_O$ and $P_O^R = P_O q$. It is assumed that $0 < \varepsilon_i < 1$ for $i = (US, R)$.

The parameter $\tilde{S}_R$ represents the R share of the total US and R consumer surplus loss due to an increase in the price of oil, where $\tilde{S}_R = \frac{Oil_R(1-\varepsilon_R)}{Oil_{US}(1-\varepsilon_{US})+Oil_R(1-\varepsilon_R)}$. The $\tilde{S}_R$ is referred to, hereafter, as the marginal burden incurred by R due to an increase in the price of oil. Similarly, the US share of the US and R consumer surplus loss is $\tilde{S}_{US} = \frac{Oil_{US}(1-\varepsilon_{US})}{Oil_{US}(1-\varepsilon_{US})+Oil_R(1-\varepsilon_R)}$, and is referred to as the US marginal burden due to an increase in the price of oil. The sum of the US and R shares of the US and R consumer surplus loss is equal to one. The OPEC producer surplus gain, also referred to as the total benefit to OPEC due to an increase in oil price, is equal to $Oil_{US}(1-\varepsilon_{US}) + Oil_R(1-\varepsilon_R) = \tilde{S}_{US}[Oil_{US}(1-\varepsilon_{US}) + Oil_R(1-\varepsilon_R)] + \tilde{S}_R[Oil_{US}(1-\varepsilon_{US}) + Oil_R(1-\varepsilon_R)]$.

Regarding equation (25), the denominator is positive since it depends on the wealth of the US, R and OPEC; hence the direction of movement of the US dollar depends on $(\alpha_R\tilde{S}_R + \alpha_{US}\tilde{S}_{US})$ *versus* (α_O).

Similar to equation (21), in the short run, a rise in the oil price causes OPEC demand for foreign assets to increase, which improves the US and R capital accounts. OPEC consumption, and accordingly OPEC imports from the US and R, does not change on impact. However, due to the increase in the oil price, the value of oil imports increases, which causes the US and R trade balances to deteriorate. The less price-elastic the demand for oil, the greater the trade balance deterioration caused by an increase in the price of oil. This is reflected in equation (25). The deterioration of the US and R trade balances would be financed by selling assets.

Hence, $(\alpha_R\tilde{S}_R + \alpha_{US}\tilde{S}_{US})$ reflects the increase in capital flows required by R – at given levels of the marginal burdens to the US and R – to offset the deterioration in the R trade balance. If the parameter α_O, which captures OPEC's demand for euro assets, is large such that $(\alpha_R\tilde{S}_R + \alpha_{US}\tilde{S}_{US} < \alpha_O)$, the US dollar depreciates against the euro in the short run. On the other hand, if OPEC's demand for euro assets is not sufficient to offset the deterioration in the R trade balance, $(\alpha_R\tilde{S}_R + \alpha_{US}\tilde{S}_{US} > \alpha_O)$, the US dollar appreciates against the euro.

Re-arranging the term $(\alpha_R\tilde{S}_R + \alpha_{US}\tilde{S}_{US})$, taking into account that $\tilde{S}_R = 1 - \tilde{S}_{US}$, gives $((\alpha_R - \alpha_{US})\tilde{S}_R + \alpha_{US})$. In the case in which the US demand for oil is less price elastic, the burden experienced by the US, $\tilde{S}_{US}$, is higher, so it is more likely that $((\alpha_R - \alpha_{US})\tilde{S}_R + \alpha_{US}) < \alpha_o$ and the US dollar will depreciate. Similarly, if R demand is less elastic, it is more likely that $((\alpha_R - \alpha_{US})\tilde{S}_R + \alpha_{US}) > \alpha_o$ and the US dollar will appreciate. In other words, the less (more) elastic the US demand for oil relative to R demand, the less (more) the contraction of US oil imports compared to R oil imports when the oil price rises, so the less likely the US dollar will appreciate (depreciate).

The price elasticity of demand for oil reflects the extent of R and US dependence on oil, and, hence, the amount of capital needed to offset the deterioration in their trade balances. The more the deterioration, the more the capital issued and the more likely the currency will depreciate. For example, if R's demand for oil is less elastic relative to that of the US, $\tilde{S}_R > \tilde{S}_{US}$, R increases the supply of euro assets by $(\alpha_R\tilde{S}_R + \alpha_{US}\tilde{S}_{US})$ which is equivalent to $((\alpha_R - \alpha_{US})\tilde{S}_R + \alpha_{US})$. If this increase is more than the increase in demand for euro assets, the euro depreciates against the US dollar.

3.3.2 The Long-Run Impact of a Change in the Price of Oil

As mentioned in the previous section, the OPEC trade balance is in equilibrium in the long run. Hence, an increase in the price of oil that raises the value of OPEC exports, $P_0 Oil$, leads to an equal rise in OPEC imports and consumption, C. Therefore, $P_0(Oil_{US}(P_O) + Oil_R(P_o q)) = C$, and hence $B_0 = 0$. From equations (7), (8), and (9), the condition for the long-run effect of an oil price increase on OPEC consumption is represented as follows:

$$\frac{dC}{dP_O} = [\, Oil_R(1 - \varepsilon_R) + Oil_{US}(1 - \varepsilon_{US})]. \qquad 26$$

Equation (26) shows that the long-run increase in OPEC consumption due to an increase in oil prices is equal to the total benefit to OPEC of an increase in oil prices. If oil imports are exogenously fixed, as assumed by Krugman (1980) and as is the case in the previous sub-section, the long-run impact on OPEC consumption collapses to equation (22) which is restated as follows:

$$\frac{dC}{dP_O} = Oil. \qquad 22$$

The comparison of equations (22) and (26) shows that the benefit to OPEC due to an increase in oil prices is smaller when the US and R price elasticity of demand for oil is different from zero.

In the long run, the exchange rate does not continue to change, so $\frac{d(\frac{dq}{q})}{dP_O} = 0$ and, following Krugman (1980), $B_{US} = B_R = B_O = 0$. To derive the condition for the long-run effect of an increase in oil prices on the exchange rate, equation (4) is substituted into equation (2) and equation (8) is used. Differentiating the outcome with respect to P_O, the long run condition is:

$$\frac{dq}{dP_O} = \frac{[\tilde{S}_R - \gamma(q)_R][Oil_{US}(1-\varepsilon_{US}) + Oil_R(1-\varepsilon_R)]}{\left[\frac{\partial T(q)}{\partial q} + \frac{\partial \gamma(q)_R}{\partial q} \cdot C)\right]}. \qquad 27$$

Equation (27) implies that the US dollar appreciates in the long run if ($\tilde{S}_R > \gamma(q)_R$) and depreciates if ($\tilde{S}_R < \gamma(q)_R$). That is, the US dollar would depreciate (appreciate) in the long run in the case where the R share in OPEC imports, $\gamma(q)_R$, is greater (less) than the burden to R due to an increase in the price of oil, $\tilde{S}_R$. The larger the R price elasticity of demand for oil, the larger is ε_R, the smaller is $\tilde{S}_R$, the more likely that $\tilde{S}_R < \gamma(q)_R$ and that the US dollar would depreciate. Similarly, the bigger is $\tilde{S}_R$, the more likely that $\tilde{S}_R > \gamma(q)_R$ and the US dollar would appreciate.[17]

Equation (27) shows that the long-run impact is influenced by the US share in OPEC imports, $\gamma(q)_{US} = 1 - \gamma(q)_R$, and the US marginal burden, $\tilde{S}_R = 1 - \tilde{S}_{US}$. Condition (27) does not include a parameter for the share of asset holdings in i's

[17] $\tilde{S}_R = \frac{Oil_R(1-\varepsilon_R)}{Oil_{US}(1-\varepsilon_{US})+Oil_R(1-\varepsilon_R)}$ while $S_R = \frac{Oil_R}{Oil}$. The ε_i is the price elasticity of demand for oil, $\varepsilon_i = -\frac{\partial Oil_i}{\partial P_O^i}\frac{P_O^i}{Oil_i} > 0$; $i = (R, US)$ and $P_O^{US} = P_O$ and $P_O^R = P_O q$. It is assumed that $0 < \varepsilon_i < 1$ for $i = (US, R)$. Hence, the smaller R's price elasticity of demand for oil, the larger R's marginal burden, $\tilde{S}_R$. The reason is that the smaller the price elasticity of demand for oil, the less the contraction in oil imports in response to an oil price increase.

portfolio, where $i = (US, O, R)$. This implies that the asset market does not have an impact in the long run, so the goods market determines the impact in the long run.

If the restrictive assumption of zero price elasticity of demand for oil is applied to equation (27), it collapses to equation (23), derived in the previous sub-section, which is the same as the long-run condition derived by Krugman (1980).

3.4 The Impact of Changes in the Supply of US Assets

Krugman (1980) and Bénassy-Quéré et al. (2007) study the impact of a change in the price of oil on the US dollar in a model where the results depend on the share of US dollar assets in OPEC's portfolio. Although their models include an asset market equilibrium condition, the impact of a change in the supply of US assets is not studied. In this sub-section, the impact of the change in the supply of US assets on the movement of the US dollar is studied. The goal is to determine the impact of an asset supply change on real exchange rate movements in a model that incorporates oil.

3.4.1 Short Run Analysis

The asset market equilibrium conditions for the US dollar and euro assets are, respectively:

$$\overline{D} = D_{US} + D_R + D_O = (1 - \alpha_{US})W_{US} + (1 - \alpha_R)W_R + (1 - \alpha_O)W_O, \qquad 28$$

and

$$\frac{1}{q}\overline{E} = \frac{1}{q}E_{US} + \frac{1}{q}E_R + \frac{1}{q}E_O = \alpha_{US}W_{US} + \alpha_R W_R + \alpha_O W_O. \qquad 29$$

Equation (28) shows that the equilibrium in the US dollar asset market implies that the total supply of US dollar assets is equal to the domestic demand by US residents, and foreign demand by R and OPEC residents for US dollar assets. Equation (29) shows that equilibrium in the euro asset market implies that the total supply of euro assets is equal to the domestic demand by R residents, and foreign demand by US and OPEC residents for euro assets.

Equation (12), the equation for total wealth of region i, is:

$$W_i = D_i + \frac{1}{q}E_i = (1 - \alpha_i)W_i + \alpha_i W_i \;; \qquad i = (US, R, O). \qquad 12$$

The variation in wealth at a given trade balance is $dW_i = dD_i + \frac{dE_i}{q} - \frac{E_i}{q}\frac{dq}{q}$, where $dD_i + \frac{dE_i}{q} = dw_i$ is the change in wealth at a given exchange rate. Hence, the equation for the variation of wealth is:

$$dW_i = dw_i - \alpha_i W_i \frac{dq}{q}\ . \qquad 30$$

In the short run, before the trade balance changes, the wealth of residents in region i changes due to changes in the exchange rate (valuation effect). In the absence of asset supply changes, wealth at a given exchange rate, w_i, is predetermined in the short run but can vary in the long run as saving and dissaving changes the amount of assets held over time. In other words, $dw_i = 0$ in the short run, and $dw_i \neq 0$ in the long run. Hence, the equation for the variation in wealth in the short run is:

$$dW_i = -\alpha_i W_i \frac{dq}{q}. \qquad 31$$

An exogenous increase in the stock of US assets represents a positive shock to the supply of US assets, and results from a US government deficit. An exogenous increase in the stock of US assets is denoted by $d\overline{D} > 0$. It is assumed that $d\overline{D}$ goes to US residents, increasing US residents' wealth, with no direct effect on R and OPEC residents' wealth. So, the exogenous shock results in an increase in the US assets held by US residents. Hence, OPEC wealth and R wealth only vary due to wealth valuation changes, as given by the specification presented in equation (31). The change in US residents' wealth with a shock to the supply of US assets becomes:

$$dW_{US} = d\overline{D} - \alpha_{US} W_{US} \frac{dq}{q}. \qquad 32$$

Totally differentiating equation (28), and using equations (31) and (32), yields:

$$d\overline{D} = (1 - \alpha_{US})(d\overline{D} - \alpha_{US} W_{US} \frac{dq}{q}) + (1 - \alpha_R)(-\alpha_R W_R \frac{dq}{q}) + (1 - \alpha_O)(-\alpha_O W_O \frac{dq}{q}).$$

33

Re-arranging equation (33) yields:

$$\alpha_{US} d\overline{D} = -\frac{dq}{q}\ [(1 - \alpha_{US})\alpha_{US} W_{US} + (1 - \alpha_R)\alpha_R W_R + (1 - \alpha_O)\alpha_O W_O]. \qquad 34$$

A rise in US assets is a shock to the asset market, and the exchange rate must adjust immediately to restore asset market equilibrium. Hence, the condition for the short-run impact of an exogenous shock to the stock of US assets on the exchange rate is:

$$\frac{dq}{d\overline{D}} = -\frac{\alpha_{US} \cdot q}{[\alpha_{US}(1-\alpha_{US})W_{US}+\alpha_O(1-\alpha_O)W_O+\alpha_R(1-\alpha_R)W_R]}. \qquad 35$$

Equation (35) implies that an exogenous positive shock to the stock of the US assets has a downward impact on the value of the US dollar in the short run. The higher the US home bias, the smaller α_{US}, and the smaller the impact of the shock on the exchange rate. If Krugman's (1980) restrictive assumption on US and R wealth is applied to this condition, which is equivalent to assuming that $\alpha_{US} = 0$, the shock to the stock of the US assets has no impact on the exchange rate.

Hypothetically, if US residents allocate all their wealth to euro assets, the increase in US residents' wealth due to the increase in their holdings of US assets caused by the shock will be transferred to euro assets. In this case, there is a complete shift away from US dollar assets which results in a US dollar depreciation; $\frac{dq}{d\overline{D}} = -\frac{q}{[\alpha_{US}(1-\alpha_{US})W_{US}+\alpha_O(1-\alpha_O)W_O+\alpha_R(1-\alpha_R)W_R]}$. On the other hand, if US residents allocate all their wealth to US dollar assets, the valuation effect on euro assets will be zero. That is equation (32) becomes $dW_{US} = d\overline{D}$. In general, equation (35) shows the increase in wealth will affect the exchange rate, which then affects the goods market.

3.4.2 Long-Run Analysis

In the long run, the exchange rate is determined in the goods market. Since wealth and asset stocks do not enter the goods market equilibrium condition, $\frac{dq}{d\overline{D}} = 0$. Specifically, following Krugman (1980), trade balances are zero in equilibrium in the long run, so $B_{US} = B_R = B_O = 0$. To derive the condition for the long-run effect of an exogenous shock to the supply of US assets on the exchange rate, equation (4) is substituted into equation (3), and the outcome is differentiated with respect to $\overline{D}$. Since $\overline{D}$

does not enter equations (3) and (4), $\frac{dq}{d\bar{D}} = 0$. Although the shock does not have a long-run impact on the exchange rate, the shock affects US wealth at a given exchange rate. Hereafter, the condition for the impact of the shock on US residents' wealth is derived.

From equations (28) and (29), the world supply of assets is equal to total wealth in the three regions:

$$\bar{D} + \frac{1}{q}\bar{E} = W_{US} + W_R + W_O. \qquad 36$$

The exogenous shock to the supply of US assets causes the world supply of assets and world wealth to rise in the long run. Using equation (36):

$$d\bar{D} + \frac{1}{q}d\bar{E} - \frac{1}{q}\bar{E}\frac{dq}{q} = dW_{US} + dW_R + dW_O, \qquad 37$$

where $d\bar{E} = 0$ because there is no change in the stock of euro assets and the focus is on an exogenous shock to the supply of US assets.

From equation (37), the change in world wealth due to the increase in the world supply of US assets at a given exchange rate is:

$$d\bar{D} = dw_{US} + dw_R + dw_O. \qquad 38$$

Also,

$$d\bar{D} = dD_{US} + dD_R + dD_O. \qquad 39$$

Using equations (28) and (30), where equation (30) takes into account that wealth in the long run changes due to saving and dissaving as well as due to the valuation effect:

$$d\bar{D} = (1 - \alpha_{US})(dw_{US} - \alpha_{US}W_{US}\frac{dq}{q}) + (1 - \alpha_R)(dw_R - \alpha_R W_R\frac{dq}{q}) + (1 - \alpha_O)(dw_O - \alpha_O W_O\frac{dq}{q}). \qquad 40$$

So,

$$d\bar{D} = (1 - \alpha_{US})dw_{US} + (1 - \alpha_R)dw_R + (1 - \alpha_O)dw_O - dq\frac{1}{q}(\alpha_{US}(1 - \alpha_{US})W_{US} + \alpha_R(1 - \alpha_R)W_R + \alpha_O(1 - \alpha_O)W_O) . \qquad 41$$

Since the exchange rate is determined in the goods market in the long run, so $\frac{dq}{d\bar{D}} = 0$, equation (41) becomes:

$$d\bar{D} = (1 - \alpha_{US})dw_{US} + (1 - \alpha_R)dw_R + (1 - \alpha_O)dw_O. \qquad 42$$

There are two assets, but three types of asset holders. To determine how US holdings of assets change, it is necessary to impose more structure. It is assumed that preferences for US assets are the same in R and OPEC, so $(1 - \alpha_R) = (1 - \alpha_O)$; therefore, $d\bar{D} = (1 - \alpha_{US})dw_{US} + (1 - \alpha_R)(dw_R + dw_O)$. Using equation (38):

$d\bar{D} = (1 - \alpha_{US})dw_{US} + (1 - \alpha_R)(d\bar{D} - dw_{US})$,

and re-arranging,

$\alpha_R d\bar{D} = (\alpha_R - \alpha_{US})dw_{US}$.

Accordingly, the condition for the impact of the exogenous shock to the supply of US dollar assets on US residents' wealth is:

$$\frac{dw_{US}}{d\bar{D}} = \frac{\alpha_R}{(\alpha_R - \alpha_{US})} \quad . \qquad 43$$

Equation (43) shows that the impact of a positive exogenous shock to the stock of US assets on US wealth is positive as long as the home bias assumption holds, $(\alpha_R - \alpha_{US}) > 0$. If $\alpha_{US} = 0$, $\frac{dw_{US}}{d\bar{D}} = 1$ while, if $\alpha_{US} = 0$ and $(\alpha_R - \alpha_{US}) > 0$, $\frac{dw_{US}}{d\bar{D}} > 1$. As α_{US} rises, $\frac{dw_{US}}{d\bar{D}}$ rises as long as$(\alpha_R - \alpha_{US}) > 0$. As mentioned above, and will be elaborated on in Section 4, Blanchard et al.'s (2005) computations show that the home bias condition – $(\alpha_R - \alpha_{US}) > 0$ – holds. US home bias tends to be high, so α_{US} tends to be small. Given the fixed world supply of assets, equations (38) and (43) imply foreign asset holdings fall when $\bar{D}$ rises, so $dw_R + dw_O = -\frac{\alpha_{US}}{(\alpha_R - \alpha_{US})}d\bar{D} < 0$.

In short, the exchange rate adjusts immediately to an asset supply shock, but in the long run $\frac{dq}{d\bar{D}} = 0$. In the long run, the positive shock to the stock of US assets causes US wealth to increase. The increase in US wealth results in an increase in US demand for US dollar assets. The initial US dollar depreciation causes a US trade surplus, the US accumulates assets, US wealth increases, and foreign wealth decreases. Over time, higher asset holdings by US residents lead to a gradual US dollar appreciation, so the US dollar eventually returns to its initial value.

4 Numerical Assessment of the Short-run and Long-run Effects of Oil Price Changes

The objective of this section is to give insight on the possibilities of US dollar movements due to oil price changes by numerically assessing the conditions derived in this chapter – particularly sub-section 3.2 which examines the case of the general asset market with exogenous oil imports – and by Krugman (1980) as well as comparing them to each other. For that purpose, two sets of data are used. One set of data divides the three-region world into the US, the rest of the OECD and oil exporters, while the other set divides the three-region world into the US, the rest of the world and oil exporters. In the Krugman (1980) model, the world is divided into the US, Germany and OPEC. When the first data set is employed, Germany is represented by data for the rest of the OECD. The goal of this analysis is to understand the predictions of Krugman's (1980) model and compare these to the predictions likely to emerge when numerically assessing the conditions derived in this chapter. The second data set extends the analysis to include the rest of the world, which is consistent with the model derived in this chapter and is more realistic since the US and oil exporters' trade partners are not limited to OECD countries. The data for oil exporters include all countries defined by Kilian (2009b) as oil exporters, as shown in Table 1-1. The data sources utilized to carry out the computations presented in this section are provided in Appendix 1-1.

The determination of the direction of US dollar movements in the short run requires knowledge of the euro share in oil exporters' portfolios. This follows from equations (21) and (21') where the direction of the short-run impact is determined by $[((\alpha_R - \alpha_{US})S_R + \alpha_{US}) - \alpha_O]$, as derived in this chapter, and by $[S_R - \alpha_O]$ as postulated by Krugman (1980).

Figure 1-5 illustrates the US share of the world and OECD countries' crude oil imports, S_{US}.[18] This figure shows that the US shares tend to have an increasing trend that levels off starting in the late 1990s, and implies that $S_R > S_{US}$. Figure 1-6 shows the $((\alpha_R - \alpha_{US})S_R + \alpha_{US})$ and S_R terms which represent the first terms in the two short-run conditions that determine the direction of the US dollar movement, as derived in sub-section 3.2 and in Krugman (1980), respectively. The R (rest of the world and rest of OECD) share of oil imports, S_R, in Figure 1-6, is equal to $(1 - S_{US})$ where S_{US} is presented in Figure 1-5. Regarding the share of euro assets in the US and R portfolios, the Blanchard et al. (2005) estimates are used as a proxy. Blanchard et al. (2005) find that the euro share in the US portfolio is 0.08, the US dollar share in the US portfolio is 0.77 and the euro share in Europe's portfolio is 0.53. In order to derive the terms presented in Figure 1-6, the Blanchard et al. (2005) computations are used so that the euro share in R's (rest of the world and rest of OECD) portfolio, α_R, is equal to 0.53; the euro share in the US portfolio, α_{US}, is equal to 0.08 in the case of the data set for the US, the rest of OECD, and oil exporters; and is equal to 0.23=1-0.77 in the case of the data set for the US, rest of the world, and oil exporters. The formulas, values, and data sources used to compute the terms in Figure 1-6 are provided in Table 1-2.

Figure 1-6 shows that the difference between $((\alpha_R - \alpha_{US})S_R + \alpha_{US})$ and α_O is expected to be smaller than the difference between S_R and α_O. In other words, when accounting for the role of the asset market in determining the short-run impact of oil price changes as postulated by the condition derived in sub-section 3.2, the movement in the US dollar in response to a change in the price of oil is smaller than that suggested by the Krugman (1980) condition.

[18] The US share of the world total crude oil imports is calculated as $\frac{US\ total\ crude\ oil\ imports}{World\ total\ crude\ oil\ imports}$. The US share of OECD countries' imports of crude oil is calculated as $\frac{US\ total\ crude\ oil\ imports}{OECD\ countries'\ crude\ oil\ imports}$.

Further to this point, as explained in sub-section 3.2.1, the US dollar is less likely to appreciate, relative to Krugman's (1980) case, if $\frac{S_{US}}{S_R} < \frac{(1-\alpha_R)}{\alpha_{US}}$.[19] Figure 1-5 shows that the US accounts for about 20 percent of world oil imports, and less than a third of OECD oil imports, which suggests $S_{US} < S_R$. Also, as noted above, the Blanchard et al. (2005) computations show that the share of foreigners' wealth holdings of US dollar assets is greater than US residents' wealth holdings of foreign assets, which implies $(1 - \alpha_R) > \alpha_{US}$. Together, the more general model implies the US dollar is less likely to appreciate following a rise in oil prices than is suggested by Krugman's (1980) more restricted model.

As for the α_O parameter to which $((\alpha_R - \alpha_{US})S_R + \alpha_{US})$ is compared in order to determine the direction of US dollar movements, Balakrishnan et al. (2009) note that oil exporters' holdings of US assets are relatively low and hard to track.[20] Balakrishnan et al. (2009, p.436) state that "a possible channel of undercounting" occurs when oil exporters purchase US assets through "private fund managers in London." Accordingly, capital flows from oil exporters to the US are embedded in industrial countries' capital flows. Ruiz and Vilarubia (2007) point out that the United Kingdom is still a considerably important financial centre for oil exporters. Using data "on currency composition of managed investment funds"[21] in 2006, De La Dehesa (2009) shows that the US dollar share of OPEC deposits is 77% while that of the euro is 18%. If the De La Dehesa (2009) data are used as a proxy for oil exporters' relative preferences for US dollar and euro assets, the euro share in the oil exporters' portfolio would be about 19% when considering US dollar and euro assets only. Also, when considering US dollar versus non-US dollar assets, the share of non-US dollar assets in oil exporters' portfolio would

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[19] Re-arranging $(\alpha_R S_R + \alpha_{US} S_{US}) < S_R$, $\alpha_{US} S_{US} < S_R(1 - \alpha_R)$. Then, $\frac{S_{US}}{S_R} < \frac{(1-\alpha_R)}{\alpha_{US}}$.

[20] As a proxy, I compute OPEC holdings of US treasury securities as a share of total foreign holdings of US treasury securities. Figure 1-8 shows that OPEC's share of US total treasury securities is around 5-6% in the whole period, except in 2003 and 2004 when it tends to be lower, whereas China's share increased from 6% in early 2000 to around 26 % in late 2010.

[21] De La Dehesa, G, O.(2009). "Will the Euro ever replace the US dollar as the Dominant Global currency?" Retrieved from http://www.realinstitutoelcano.org/wps/portal/rielcano_eng/Content?WCM_GLOBAL_CONTEXT=/elcano/elcano_in/zonas_in/international+economy/dt54-2009 .

be 23%.[22] Using these proxy values as well as the data presented in Figure 1-6, the condition derived in this chapter and by Krugman (1980) would yield short-run US dollar appreciation for both the case of the US dollar versus the euro and the case of the US dollar versus non-US dollar currencies. However, the condition derived in this chapter shows less US dollar appreciation.[23]

In summary, in the more general model, the condition for a US dollar appreciation is $[(\alpha_R-\alpha_{US})S_R+\alpha_{US}]>\alpha_O$ compared to $S_R>\alpha_O$ for Krugman. Results in Figure 1-6 show $[(\alpha_R-\alpha_{US})S_R+\alpha_{US}]$ is only approximately one half to two thirds as large as S_R. For example, in 2001-2008, S_R (measured for the rest of the world) is approximately 0.75, while $[(\alpha_R-\alpha_{US})S_R+\alpha_{US}]$ is only about 0.45. This suggests that the condition for a currency appreciation to occur in the more general model is less likely than in Krugman's model. Further, data for the share of US dollar assets in OPEC portfolios, α_O, is hard to track, but data from De La Dehesa (2009) suggest α_O is 0.77. Given the estimate of $[(\alpha_R-\alpha_{US})S_R+\alpha_{US}]$ for 2001-2008 is approximately 0.45, this suggests a US dollar depreciation is more likely than an appreciation.

[22] Regarding OPEC preferences for foreign assets, the Blanchard et al. (2005) approach to computing the share of US assets in foreign portfolios can be pursued to calculate the share of US assets and euro assets in OPEC's portfolio. The Blanchard et al. (2005) approach requires knowledge of the share of foreign portfolio investment (FPI) allocated by OPEC in the US, the share of foreign direct investment (FDI) allocated by OPEC in the US, the relative importance of FPI in OPEC total foreign investment, the relative importance of FDI in OPEC total foreign investment and the share of assets denominated in domestic currencies in OPEC's portfolio. However, this is not possible due to data availability issues. The International Monetary Fund (IMF) Coordinated Portfolio Investment Survey (CPIS) data-Geographic Breakdown tables provide data on the amount of FPI carried out by the US in Saudi Arabia, for example, but not vice versa. The Bank of International Settlements (BIS) provides consolidated banking statistics on an immediate borrower basis which provide data on foreign claims on the banking system in reporting regions and countries. This dataset can be used to compare the liabilities on the banking system in the US versus European countries. But it does not reflect the increase in OPEC demand for US dollar and euro assets. The currency composition of official foreign exchange reserves (COFER) dataset provides data on "currency composition of official foreign exchange reserves. .... COFER data for individual countries are strictly confidential", however (http://www.imf.org/external/np/sta/cofer/eng/index.htm).

[23] The case of endogenous oil imports is not numerically assessed in this chapter due to data availability issues. In order to account for the effect of different price elasticities of demand for oil, the term $\left((\alpha_R-\alpha_{US})\tilde{S}_R+\alpha_{US}\right)$, as explained in section 3.3.1 and presented in equation (25), is to be examined. However, the S_R and $\tilde{S}_R$ terms are almost the same in the short run because the short-run price elasticity of demand for oil is small as shown in Hamilton (2009), Cooper (2003), and Ye et al. (2003). Hence, accounting for different price elasticities of demand for oil is not likely to alter the results in the short run. Reminder: the $\tilde{S}_R$ represents the marginal burden incurred by R due to an increase in the price of oil, where $\tilde{S}_R=\frac{Oil_R(1-\varepsilon_R)}{Oil_{US}(1-\varepsilon_{US})+Oil_R(1-\varepsilon_R)}$, and $\tilde{S}_{US}=\frac{Oil_{US}(1-\varepsilon_{US})}{Oil_{US}(1-\varepsilon_{US})+Oil_R(1-\varepsilon_R)}$. The ε_i is the price elasticity of demand for oil, $\varepsilon_i=-\frac{\partial Oil_i}{\partial P_O^i}\frac{P_O^i}{Oil_i}>0$; $i=(R,US)$ and $P_O^{US}=P_O$ and $P_O^R=P_O q$. It is assumed that $\varepsilon_i\epsilon(0,1)$.

Regarding the long-run condition, sub-section 3.2 and Krugman (1980) find that the movement of the US dollar in the long run is influenced by the US share of oil imports and the US share of exports to oil exporters and, hence, by the parameters S_R and γ_R as shown in equation (23).[24] These two parameters are presented in Figures 1-6 and 1-7, respectively, where data for γ_R, when using the data set that accounts for the US versus the rest of the world, are available starting in 1995. Figure 1-6 and Figure 1-7 show that it is more likely to have a long-run US dollar appreciation when using the data for the US versus the rest of the OECD countries. However, a long-run US dollar depreciation is more likely when using the data set that accounts for the US versus the rest of the world. This means that data that capture a wider and more realistic scope of oil exporters' demand for goods show that they prefer non-US goods. This is more obvious for the data on the US and the rest of the world, as the rest of the world includes Asian countries, for example, and as indicated by Ruiz and Vilarubia (2007), oil exporters have a preference for Asian goods.[25]

5 Conclusion

The present research builds on Krugman (1980) to incorporate the oil price and the supply of US assets in a model of exchange rate determination. Krugman (1980) and Bénassy-Quéré et al. (2007) assume that US (R) residents hold a fixed value of euro (US dollar)-denominated assets. This assumption is restrictive as it implies absolute home bias with regard to additions to wealth. Hence, this assumption is relaxed such that the US and R residents' holdings of all assets increase when their wealth increases. This is carried out by allowing the US and R residents to hold fixed shares of their wealth in US dollar and euro assets, rather than a fixed value of the other country's assets. Such an

[24] The rest of the world share of the world total exports to oil exporters, γ_R, is calculated as $(1 - \frac{US\ exports\ to\ oil\ exporters}{World\ total\ exports\ to\ oil\ exporters})$. The rest of OECD share of OECD countries' exports to oil exporters, γ_R, is calculated as $(1 - \frac{US\ exports\ to\ oil\ exporters}{OECD\ countries'\ total\ exports\ to\ oil\ exporters})$. The rest of the world share of the world total crude oil imports, S_R, is calculated as $(1 - \frac{US\ total\ crude\ oil\ imports}{World\ total\ crude\ oil\ imports})$. The rest of the OECD share of OECD countries' imports of crude oil, S_R, is calculated as $(1 - \frac{US\ total\ crude\ oil\ imports}{OECD\ countries'\ crude\ oil\ imports})$.

[25] The case of endogenous oil imports is not numerically assessed in this chapter due to data availability issues on oil price elasticities over the time sample and country sample of interest. .

extension allows for the interaction of the asset market and the oil market. It shows that the short-run impact of oil price changes is affected by asset market parameters. On the other hand, the long-run impact is determined by the goods market and is not affected by the asset market.

Krugman (1980) states that the results of his model will be affected if the price elasticity of demand for oil differs from zero and differs across regions. However, he does not derive the short-run and long-run conditions for this case. In this chapter, this case is examined by further extending the model of exchange rate determination with the more general asset market to incorporate the case with endogenous oil imports. Accordingly, in addition to the general asset market, the US demand for oil is specified to be a function of the real US dollar price of oil, while the R demand for oil is specified to be a function of the real euro price of oil. It is shown that the smaller (larger) the R share of the US and R consumer surplus loss due to an oil-price increase – i.e., the larger (smaller) the US share of the US and R consumer surplus loss – the less likely the US dollar will appreciate (depreciate). In other words, the less (more) price-elastic the US demand for oil relative to R demand, the less (more) the contraction of US oil imports compared to R oil imports when oil prices rise, so the less likely the US dollar will appreciate (depreciate).

As regards the impact of a change in the supply of US assets, an exogenous positive shock is likely to put downward pressure on the US dollar in the short run. In the long run, the exchange rate is determined in the goods market, and the goods market equilibrium condition is not a function of wealth or asset stocks. Hence, the exogenous shock to the supply of US assets does not affect the US dollar in the long run.

This chapter also provides a numerical assessment of the impact of oil price changes comparing the short run and long run conditions derived here to the ones derived by Krugman (1980). The numerical assessment suggests that long-run US dollar depreciation is more likely in the case of a three-region world that consists of the US, the rest of the world and oil exporters than in the case of a three-region world that consists of the US, the rest of the OECD countries and oil exporters. This means that data on oil exporters' demand for goods that capture a wider range of their preferences indicate that oil exporters prefer non-US goods. As for the short-run impact, the condition derived in this chapter predicts a smaller impact than that postulated by Krugman (1980), and implies that the US dollar is less likely to appreciate in the short run relative to the condition derived in Krugman (1980).

These extensions of the Krugman (1980) model serve to provide a more general model that captures the different possibilities of short-run and long-run appreciation and depreciation of the US dollar. This makes it possible to explain the empirical results of analyses which examine the interaction of the asset and oil markets in a model of exchange rate determination.

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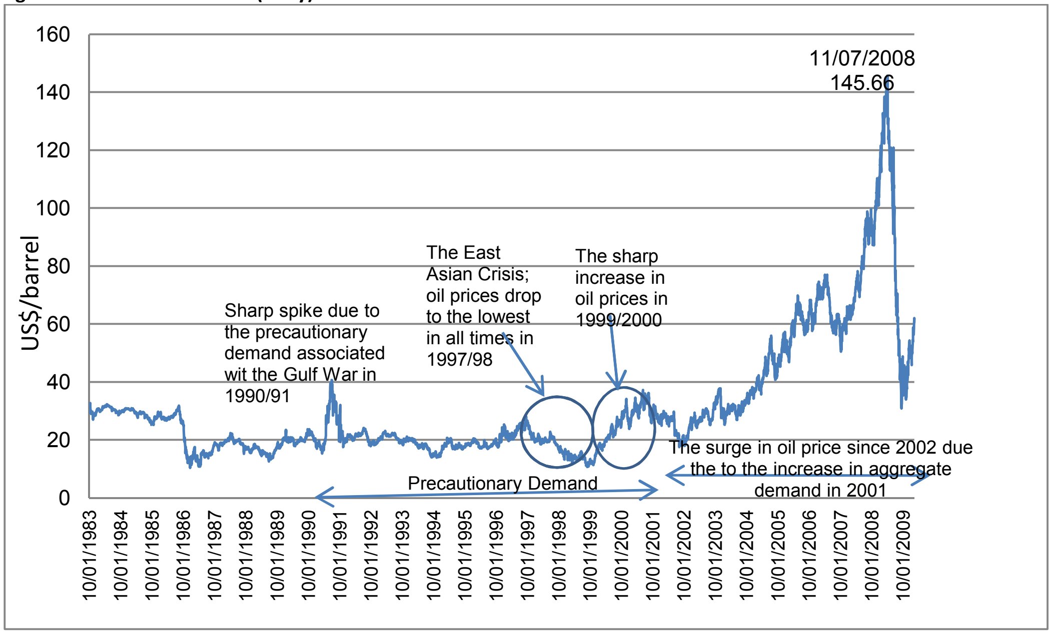
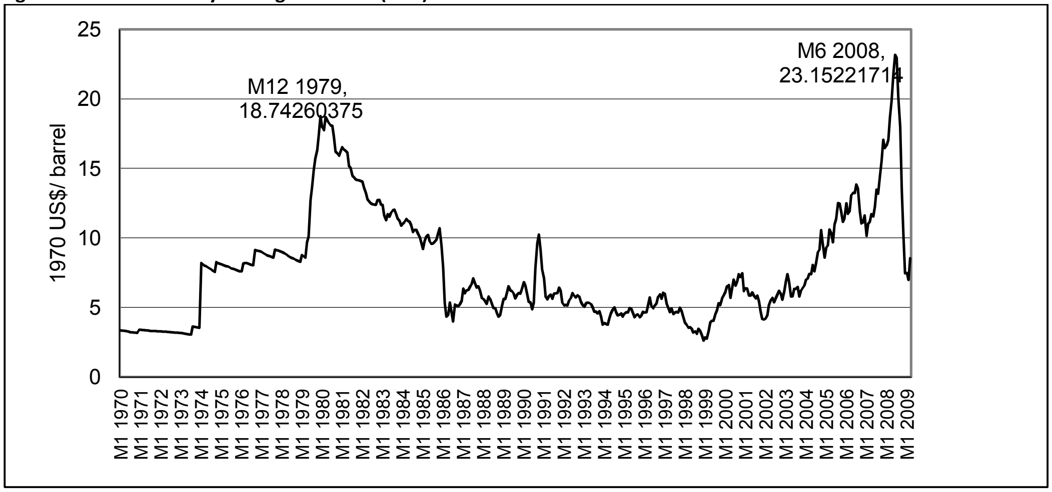
Figures

Figure 1-1: The WTI Oil Price (Daily)



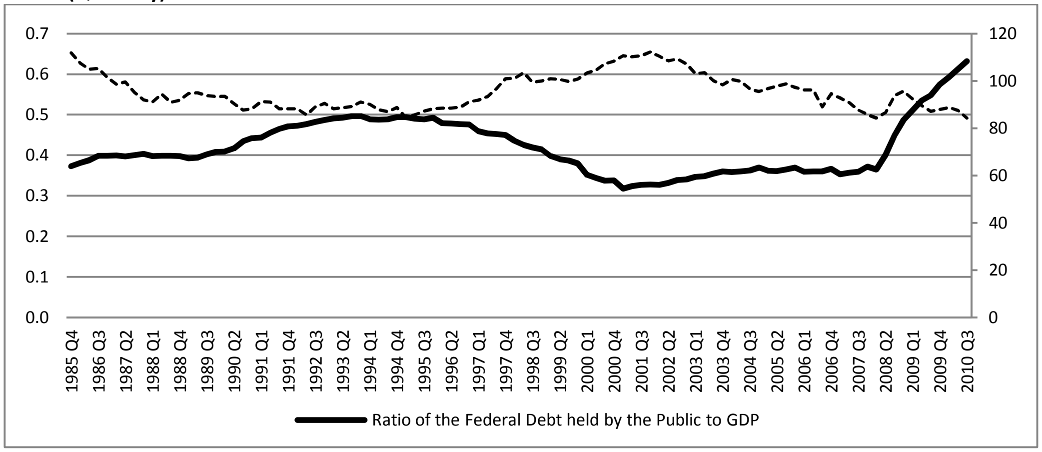
Source: DataStream.

Figure 1-2: Real Monthly Average Oil Price (WTI)



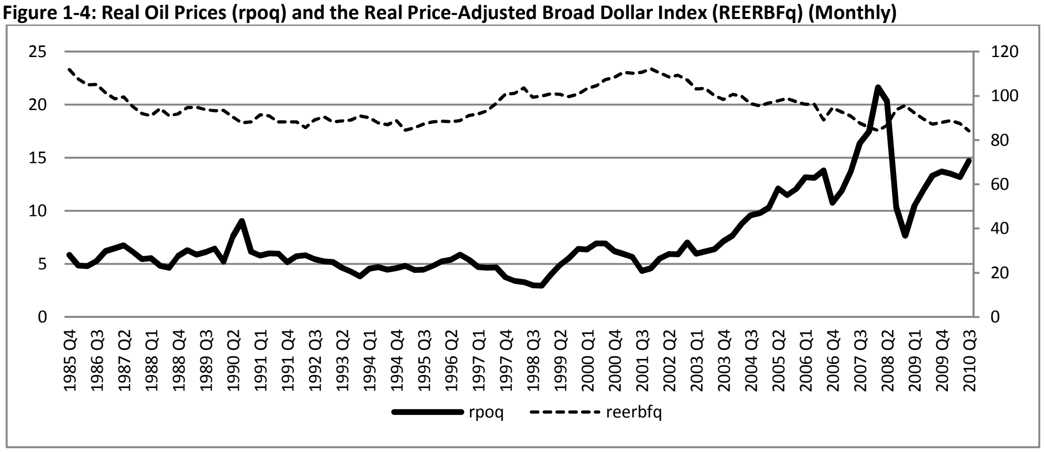
Source: The source for the WTI price and the consumer price index (CPI) is the International Financial Statistics (IFS).

Figure 1-3: The Real Price-Adjusted Broad Dollar Index (REERBFq), the Ratio of the Federal Debt held by the Public to GDP (Quarterly)



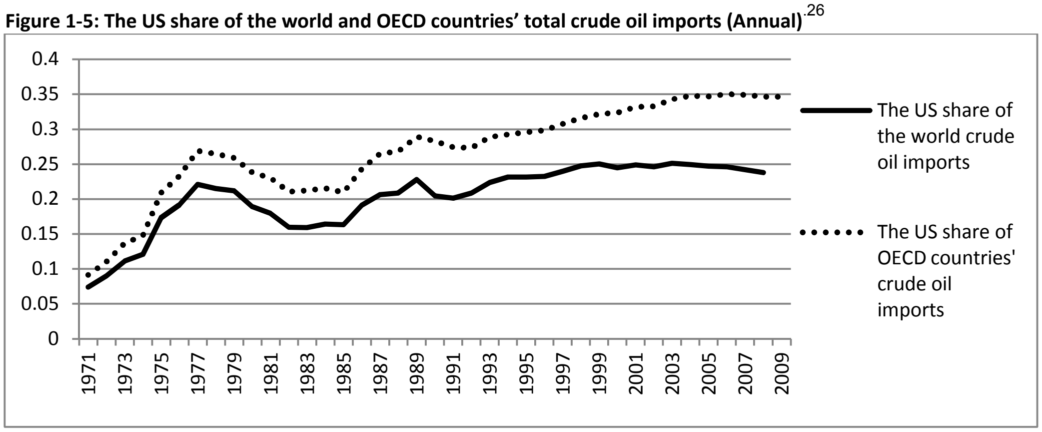
Source: The Broad Dollar Index is on the secondary axis, and the ratio of the US federal debt held by the public to GDP is on the primary axis. The source of the Broad Dollar Index is the US Federal Reserve, the source of the US GDP is the Bureau of Economic Analysis (BEA), and the source the US federal debt held by the public is the Federal Reserve Bank of St. Louis (FRED).

Figure 1-4: Real Oil Prices (rpoq) and the Real Price-Adjusted Broad Dollar Index (REERBFq) (Monthly)



Source: The source for rpoq (on the primary axis) is the IFS and the source for REERBFq (on the secondary axis) is the US Federal Reserve.

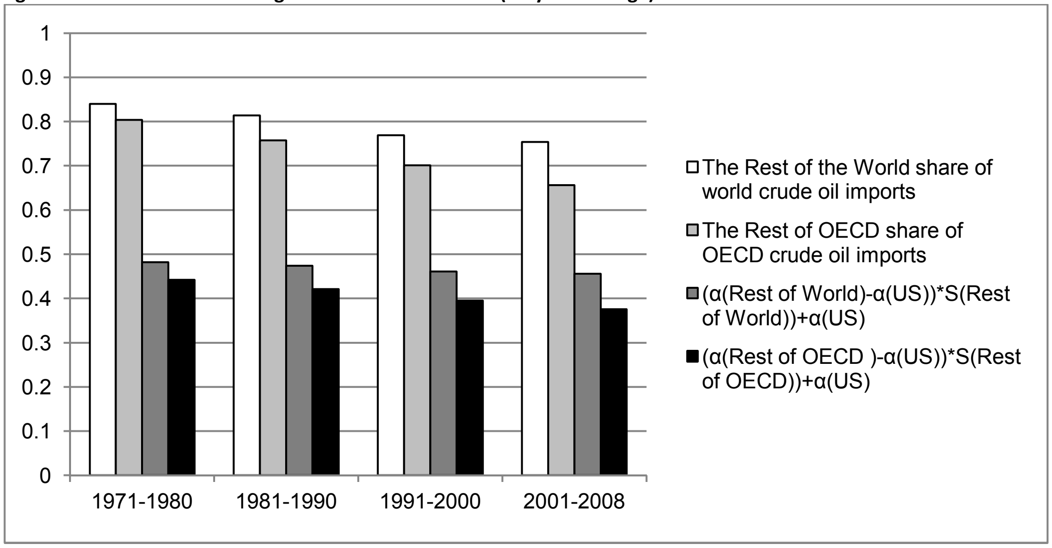
Figure 1-5: The US share of the world and OECD countries' total crude oil imports (Annual)[26]



Source: Author's calculations using data from the International Energy Agency.

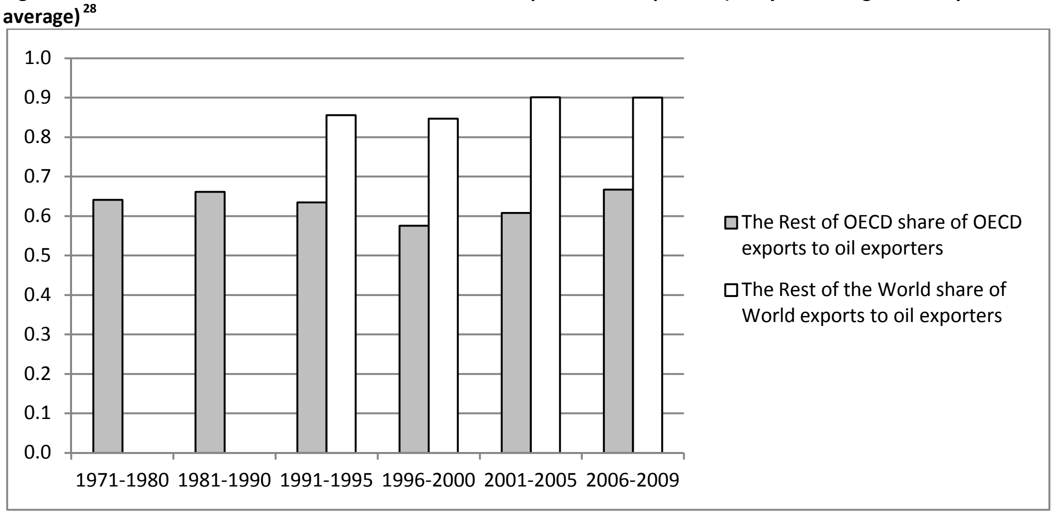
[26] The US share of the world total crude oil imports is calculated as $\frac{US\ total\ crude\ oil\ imports}{World\ total\ crude\ oil\ imports}$. The US share of OECD countries' imports of crude oil is calculated as $\frac{US\ total\ crude\ oil\ imports}{OECD\ countries'\ crude\ oil\ imports}$.

Figure 1-6: Parameters affecting the short run condition (10-year average) [27]



Source: Author's calculations using data on US, OECD total, World crude oil imports from the International Energy Agency, and on the euro share in the US and R (Rest of the World and Rest of OECD) portfolios, and the US dollar share in US portfolio from Blanchard et al. (2005). According to Blanchard et al. (2005), the euro share in the US portfolio is 0.08, the euro share in Europe's portfolio is 0.53, and the US dollar share in the US portfolio is 0.77. Here, the euro share in Europe's portfolio (0.53) is used as a proxy for the euro share in R's (the Rest of OECD and Rest of the World) portfolio, the euro share in US portfolio (0.08) is used as a proxy for the euro share in the US portfolio in the case of the data set for the US and the rest of OECD countries, and the euro share in US portfolio (1-0.77) is used as a proxy for the euro share in the US portfolio in the case of the data set for the US and the rest of the world. For details, refer to Table 1-2.

Figure 1-7: The R share of the world and OECD countries' exports to oil exporters (five-year average and 10-year average) [28]



Source: Author's calculations using data from SourceOECD Monthly Statistics of International Trade Total Trade in Value by Partner Countries and UNCTAD Handbook of Statistics. Data from UNCTAD on the world and US exports to oil exporters are available starting in 1995.

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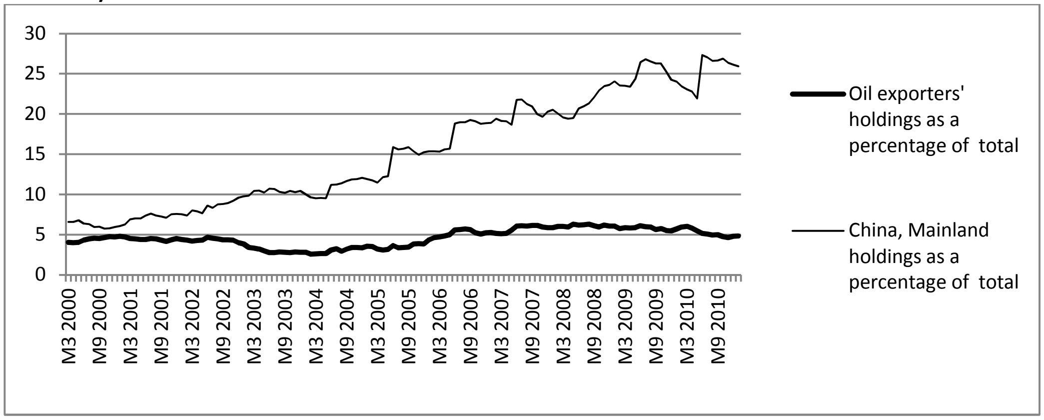
[27] The rest of the world share of the world total crude oil imports is calculated as $[1 - \frac{US\ total\ crude\ oil\ imports}{World\ total\ crude\ oil\ imports}]$. The rest of OECD share of OECD countries' imports of crude oil is calculated as $[1 - \frac{US\ total\ crude\ oil\ imports}{OECD\ countries'crude\ oil\ imports}]$.

[28] The rest of the world share of the world exports to oil exporters is calculated as $[1 - \frac{US\ exports\ to\ oil\ exporters}{World\ total\ exports\ to\ oil\ exporters}]$. The rest of OECD share of OECD countries' total exports to oil exporters is calculated as $[1 \frac{US\ exports\ to\ oil\ exporters}{OECD\ countries'\ total\ exports\ to\ oil\ exporters}]$.

Figure 1-8: OPEC and Chinese holdings of US Treasury Securities as a percentage of the total foreign holdings of the US Treasury Securities



Source: Treasury International Capital System (TIC), US Department of Treasury.

Tables

Table 1-1: List of OPEC and Major Oil Exporting Countries

	OPEC (10 countries)	Major Oil Exporters	
		UNCTAD (22 countries)	Kilian et al. (2009) (26 countries)
1. Algeria	√	√	√
2. Angola		√	√
3. Azerbaijan			√
4. Bahrain		√	√
5. Congo		√	√
6. Ecuador		√	√
7. Equatorial Guinea		√	√
8. Gabon		√	√
9. Indonesia	√	√	√
10. Iran	√	√	√
11. Kazakhstan			√
12. Kuwait	√	√	√
13. Libya	√	√	√
14. Mexico			√
15. Nigeria	√	√	√
16. Norway			√
17. Oman		√	√
18. Qatar	√	√	√
19. Saudi Arabia (SA)	√	√	√
20. Sudan		√	√
21. Syria		√	√
22. Trinidad and Tobago		√	√
23. Turkmenistan			√
24. United Arab Emirates (UAE)	√	√	√
25. Venezuela	√	√	√
26. Yemen		√	√

Source: Kilian et al. (2009) and UNCTAD (URL: http://www.unctad.org/sections/stats/docs//gds_csirb_c&td-2-5_en.pdf)

Table 1-2: Formulas used to compute the terms presented in Figure 1-6

Column Name	Formula(s) used in computation	Varies over the time period	Assumed to be fixed	Source
The Rest of the World share of world crude oil imports	$S_R = S(Rest\ of\ World) = [1 - \frac{US\ total\ crude\ oil\ imports}{World\ total\ crude\ oil\ imports}]$	√		International Energy Agency
The Rest of OECD Share of OECD crude oil imports	$S_R = S(Rest\ of\ OECD) = [1 - \frac{US\ total\ crude\ oil\ imports}{OECD\ countries'crude\ oil\ imports}]$	√		International Energy Agency
(α(Rest of World)-α(US))*S(Rest of World))+α(US)	$\alpha(Rest\ of\ World) = 0.53$		√	Blanchard et al. (2005)
	$\alpha(US) = 0.23 = 1 - 0.77$		√	Blanchard et al. (2005)
	$S_R = S(Rest\ of\ World) = [1 - \frac{US\ total\ crude\ oil\ imports}{World\ total\ crude\ oil\ imports}]$	√		International Energy Agency
(α(Rest of OECD)-α(US))*S(Rest of OECD))+α(US)	$\alpha(Rest\ of\ OECD) = 0.53$		√	Blanchard et al. (2005)
	$\alpha(US) = 0.08$		√	Blanchard et al. (2005)
	$S_R = S(Rest\ of\ OECD) = [1 - \frac{US\ total\ crude\ oil\ imports}{OECD\ countries'crude\ oil\ imports}]$	√		International Energy Agency

Appendices

Appendix 1-1: Data Sources

	Variable	Source	Unit
	List of Oil exporting countries	United Nations Conference on Trade and Development; URL: http://www.unctad.org/sections/stats/docs//gds_csirb_c&td-2-5_en.pdf	
$\gamma(q)_R$ $\gamma(q)_{US}$	The US and the rest of the world's shares of world exports to Major Oil Exporters	UNCTAD Handbook of Statistics 2009 URL:http://stats.unctad.org/Handbook/ReportFolders/reportFolders.aspx	Annual frequency
$\gamma(q)_R$ $\gamma(q)_{US}$	The US and rest of OECD countries' shares of OECD exports to oil exporters	SourceOECD Monthly Statistics of International Trade Total Trade in Value by Partner Countries - Annual Vol 2010 release 08 http://titania.sourceoecd.org.login.ezproxy.library.ualberta.ca/vl=12469349/cl=17/nw=1/rpsv/~4256/v185n1/s9/p1	Annual frequency
S_R S_{US}	The US and rest of OECD countries' shares of OECD crude oil imports, and the US and the rest of the world's shares of world crude oil imports	IEA World Energy Statistics and Balances, International Energy Agency. Retrieved from http://stats.oecd.org/BrandedView.aspx?oecd_bv_id=enestats-data-en&doi=data-00514-en	Annual frequency
α_{US} α_R	The euro share in US and R portfolios	Blanchard et al. (2005) $\alpha_R = 0.53$ In the case of the US versus the rest of OECD countries, it is assumed that $\alpha_{US} = 0.08$. In the case of the US versus the rest of the world, it is assumed that $\alpha_{US} = 0.23$. These values assigned to α_R and α_{US} are assumed to be fixed.	
α_O	The euro share in oil exporters portfolio	De La Dehesa, G. O. (n.d). "Will the Euro ever replace the US dollar as the Dominant Global currency?" Retrieved from http://www.realinstitutoelcano.org/wps/portal/rielcano_eng/Content?WCM_GLOBAL_CONTEXT=/elcano/elcano_in/zonas_in/international+economy/dt54-2009 $\alpha_O = 19\%$	

Chapter 2: The Role of Oil Prices and Government Debt as Determinants of Movements in the US Dollar in a Dynamic Empirical Framework

Abstract

An Error Correction Model of the US dollar that incorporates the supply and demand components underlying oil price changes, as well as the US federal debt is estimated using quarterly data for the period 1986-2010. The global-aggregate-demand oil-price-effect, the precautionary-demand oil-price-effect, and the federal debt are shown to be significant short- and long-run determinants of US dollar movements. An increase in the oil price, and in the components underlying oil price changes, causes the US dollar to depreciate in the short run and the long run. According to a portfolio balance model, this finding is consistent with a situation where oil exporters tend to have a higher preference for non-US goods and assets. An increase in the supply of US dollar assets, through an increase in the federal debt, has a downward effect on the US dollar; this is consistent with theoretical predictions of portfolio balance models and with the empirical literature. The robustness of the results is confirmed by examining the impact of additional explanatory variables, by testing for weak exogeneity and Granger causality for the oil price and the US dollar, by accounting for seasonality, and by using an alternate US dollar exchange rate measure.

Keywords: US dollar, oil prices, US government debt, Error Correction Model, global aggregate demand.

1 Introduction

The 2007/08 oil price shock was historic for two reasons. First, oil prices continuously increased to extraordinary levels, reaching US$145/barrel in July 2008 from a minimum of around US$10/barrel in 1998. Second, unlike previous oil price shocks, the 2007/08 shock is considered to have been mainly driven by increasing global economic activity (Kilian and Park, 2009; Kilian, 2009b; and Kilian et al., 2009). The latter increase resulted in an increase in the global demand for oil, causing oil exporters' revenues to increase beyond their consumption capacity; accordingly, there was an increase in global savings directed to the US (Bernanke, 2007; Caballero, et al., 2008). In addition, the US government relied on the issuance of government debt to finance its budget deficit, causing an increase in the federal debt held by the public as a percentage of nominal Gross Domestic Product (GDP) from around 36% in 2006:Q3, and around 45% by the end of 2008, to around 63% by the end of 2010 (see Figure 2-7).

Little of the empirical research on the relationship between the US dollar and the price of oil accounts for the impact of government debt. See, for example, Amano and Van Norden, 1998a and 1998b; Chaudhuri and Daniel, 1998; Chen and Chen, 2007; Coudert et al., 2008; and Bénassy-Quéré et al., 2007. As well, there are only a few empirical studies that examine the relationship between government debt and the exchange rate (McMillin and Koray, 1990; and Cayen et al., 2010); and only Cayen et al. (2010) account for the impact of both oil prices and government debt. The objective of Chapter Two is to use the portfolio balance model developed in Chapter One to study empirically the role of oil prices and government debt as determinants of movements in the US dollar in a dynamic framework.

A key contribution of this chapter is that it provides an empirical model of the US dollar that incorporates the demand and supply components of oil price movements, as well as asset market factors represented by the ratio of the federal debt held by the public to GDP. The second empirical contribution is that an Error Correction Model (ECM) is employed to provide estimates of the short- and long-run effects of oil-price and government-debt changes on the exchange rate, which is important since portfolio balance models suggest that these effects may differ. The current research differs from Cayen et al. (2010) in that I use the US real price-adjusted broad dollar exchange rate index, whereas Cayen et al. (2010) use a panel of US bilateral real exchange rates. The price of oil and the government debt are both factors Cayen et al. (2010) examine as determinants of the exchange rate. However, they estimate only the long-run effects of these variables, whereas the current research is able to estimate both the short- and long-run effects. Also, Cayen et al. (2010) do not account for the source of oil price changes, a key contribution of the current research.

McMillin and Koray (1990) show empirically that an increase in government debt causes the US dollar to depreciate in the short run, while Cayen et al. (2010) show it causes the US dollar to depreciate in the long run. Using theoretical portfolio balance analysis, Chapter One shows that an asset supply increase causes the US dollar depreciate in the short run, although not in the long run, and Bernanke (2005b) shows that the US dollar depreciates in the short and long run due to an exogenous increase in the value of US assets.

Regarding the change in oil prices, Amano and Van Norden (1998a and 1998b), Chaudhuri and Daniel (1998), Chen and Chen (2007), Coudert et al. (2008), and Bénassy-Quéré et al. (2007) apply time series analysis to study the relationship between oil price changes and US dollar movements over the post-Bretton Woods period. The general finding is that there exists a stable, positive relationship between oil prices and the US dollar in which an increase in oil prices causes the US dollar to appreciate. The theoretical portfolio balance analyses of Krugman (1980) and Bénassy-Quéré et al. (2007) show that, in the short run, the increase in oil prices may lead to an increase in the value of the US dollar if oil exporters demand mainly US dollar assets as their wealth increases, while in the long-run that effect can be reversed if oil exporters' demand for US goods is not sufficiently strong. In Chapter One, the derived short-run condition shows that, with a more general asset-market specification than that employed by Krugman

(1980), US dollar appreciation is less likely.

Kilian (2009a) and Hamilton (2009) explain that the recent increase in oil prices is attributed to the increase in global real economic activity. Kilian (2009b) argues that he can explain the puzzle of why the increase in oil prices between 2003 and 2007 was not followed by a major US recession. His explanation is that the increase was driven primarily by a strong demand for oil fuelled by a booming world economy rather than oil supply disruptions. Given the response of US GDP, one might also expect the change in oil prices arising from demand shocks to affect the exchange rate differently than would a change in oil prices arising from oil supply shocks.

One empirical contribution of this Cahpter is to separate the effect of global demand shocks through oil prices from the effect of oil price shocks driven by other sources, such as oil supply disruption shocks. In order to identify the global-aggregate-demand-oil-price-effect, an ordinary least squares (OLS) regression is carried out where the price of oil is regressed on a constant and an index developed by Kilian (2009b) to capture global aggregate economic activity. The predicted values from this regression represent global-aggregate-demand-oil-price movements, and the residuals represent the oil supply and precautionary demand components of oil price movements. The predicted values and the residuals are then included in the ECM. The results show that both types of oil-price movements have a negative and significant impact on the US dollar in both the short run and the long run with the global-aggregate-demand oil-price effect being about twice as large as the oil-supply-and-precautionary-demand oil-price effect. Peersman and Robays (2009) account for the source of oil price changes in studying the movements in the US dollar-euro exchange rate; however, they do not study the impact of government debt. As well, the approach undertaken in this chapter to separate demand and supply components of oil price movements is different from the Kilian (2009b) approach applied by Peersman and Robays (2009) in that it distinguishes the short- and long-run effects, and the speed of adjustment towards the long-run equilibrium.

The negative impact of the two types of oil price movements on the US dollar contrasts with the previous empirical research that studies the post-Bretton Woods period and does not account for the source of oil price changes. Another empirical contribution is that the ECM is estimated using the price of oil in place of the two types of oil price movements. The results show that the price of oil and government debt variables still have significant negative effects in the short run and the long run.

The remainder of the chapter is organized as follows: The second section provides a literature review of portfolio balance analysis that serves to clarify the relationship between the variables of concern, and reviews the empirical literature on the US dollar and the price of oil, and on the exchange rate and government debt. It also discusses disentangling oil-price shocks and the relationship between the exchange rate and commodity prices. The third section discusses the main hypotheses examined in this chapter. The fourth, fifth, sixth, and seventh sections present the empirical methodology, data, the results, and the robustness of the results, respectively. The eighth section concludes the chapter.

2 Literature Review

This section provides a review of the theoretical and empirical literature on the relationship between the US dollar and the price of oil, and on the relationship between the exchange rate and government debt. In addition, the related issues of the relationship between the US dollar and commodity prices, relative prices, interest rate differentials, and external imbalances are covered.

2.1 Theoretical Portfolio Balance Analysis

Krugman (1980) shows that, if oil exporters have a sufficiently strong preference for US assets compared to non-US assets, the US dollar appreciates in the short run due to an increase in the price of oil. Krugman (1980) also shows that, given the assumption that OPEC prefers non-US goods, the US dollar depreciates in the long run. By adding China to Krugman's (1980) model, Bénassy-Quéré et al. (2007) explain that the diversification of Chinese official reserves away from the US dollar would more likely result in long-run US dollar depreciation. Blanchard et al. (2005) show that an increase in foreign demand for US assets is likely to result in short-run appreciation and long-run depreciation of the US dollar. The less substitutable US and foreign assets, the larger the initial appreciation and the larger the expected depreciation in the long run.

As for the impact on the exchange rate of an exogenous increase in the supply of domestic assets, holding constant the supply of all other assets, which is the concern of the current research because it captures the impact of an increase in government debt, Branson et al. (1977) find ambiguous results, while Branson and Henderson (1985) find that the domestic currency depreciates. Bernanke (2005b) shows that the short-run effect of an increase in the value of US assets is a US dollar depreciation, and the long-run effect is further US dollar depreciation. The reason is that the increase in the value of US assets results in an increase in wealth causing the trade balance to deteriorate. Moreover, the depreciation means foreign investors are induced to buy more US assets to compensate for the decrease in the value of the US dollar caused by the increase in the supply of US assets. Consequently, US foreign debt accumulation increases and the US dollar depreciates further over time (Bernanke, 2005b).

The portfolio balance model developed in Chapter One builds on the models of Krugman (1980) and Bénassy-Quéré et al. (2007) which include an asset market equilibrium condition, but do not study the impact of changes in the supply of US assets. Chapter One shows that the short-run impact of oil price changes is affected by the extent of home bias for assets, and that, with a more general asset-market specification, short-run US dollar appreciation is less likely relative to Krugman (1980). In addition, an exogenous increase in the supply of US assets is likely to cause the US dollar to depreciate in the short run, but not in the long run. This result is consistent with Bernanke's (2005b) case in which wealth does not affect consumption.

2.2 Empirical Literature Review

2.2.1 Empirical Studies on Oil Prices and Exchange Rates

While nominal exchange rate models have often been observed to have poor forecasting power (Meese and Rogoff, 1983), macroeconomic variables can help explain movements in the real exchange rate over the medium term (Engle, Mark and West, 2007; Rogoff, 2007), particularly for currencies of commodity exporters (Chen and Rogoff, 2003). Amano and Van Norden (1998a and 1998b), Chaudhuri and Daniel (1998), Chen and Chen (2007), Coudert et al. (2008), and Bénassy-Quéré et al. (2007) empirically find that oil price changes cause exchange rate movements. All of these studies apply time-series techniques using monthly data over the post-Bretton Woods period for mostly oil-importing countries. Amano and Van Norden (1998a and 1998b) and Chaudhuri and Daniel (1998) study the time period from the early seventies until the early nineties. The Coudert et al. (2008) sample starts in the mid-1970s and extends to the late 1990s. The Bénassy-Quéré et al. (2007) sample starts in the mid 1970s and ends in 2004. The general results of these empirical studies are that oil prices and exchange rates are non-stationary, and that there exists a stable positive relationship between the two variables in the long run in which an increase in the oil price causes the US dollar to appreciate. This generally holds whether bilateral or trade-weighted exchange rates are employed in the analysis, and whether variables are deflated by the Consumer Price Index (CPI) or the Producer Price Index (PPI). The results also hold for all oil price measures considered. Regarding the direction of causality, Chaudhuri and Daniel (1998), Amano and Van Norden (1998a) and Bénassy-Quéré et al. (2007) show that oil prices are weakly exogenous whereas the exchange rate is not.

What follows is a presentation of this literature classified by whether a trade-weighted exchange rate or a bilateral exchange rate is used as the dependent variable. It is beneficial to follow this classification as Pauls and Helkie (1987, p. 27-28) state that “no single measure is appropriate for all applications.” As well, it may be argued that results differ depending on whether a bilateral exchange rate or a multilateral trade-weighted exchange rate is used because, as explained by Pauls and Helkie (1987), multilateral trade-weighted exchange rates are affected by different aspects such as the weighting mechanism, the choice of the base year for the assigned weights, the country coverage, whether the index is real or nominal, and the measure used as the deflator.

Trade-Weighted Exchange Rate

In Amano and Van Norden (1998a), the exchange rate measure used is the Morgan Guaranty 15-country real effective exchange rate series for Germany, Japan, and the US. The measure used for the oil price is the US price of West Texas Intermediate (WTI), which is converted to the respective domestic currency and deflated by the respective CPI. Amano and Van Norden (1998a, p.685) "use real oil prices as a proxy for exogenous changes in the terms of trade (TOT)"[29] to examine how the respective domestic oil prices explain the permanent movements in the respective measure of the exchange rate. Tests for cointegration show that an increase in oil prices causes the German mark and Japanese yen to depreciate, while it causes the US dollar to appreciate.

Amano and Van Norden (1998b) focus on the US dollar and use the same measures for the exchange rate and real oil price as Amano and Van Norden (1998a). Applying an ECM, it is found that a stable positive relationship exists between oil price shocks and the US dollar in the long run. Furthermore, real interest rate differentials add no significant explanation to short- and long-run changes in exchange rates.[30]

Amano and Van Norden (1998a) state that the positive long-run relationship between oil prices and the US dollar may seem counterintuitive as the US is a major oil importer. That is, since the US is an oil importer, in the long run oil price increases are expected to lead to a depreciation, rather than an appreciation, of the US dollar. On the

[29] Amano and Van Norden (1998a) graphically inspect the relationship between the domestic real price of oil and TOT for the US, Japan and Germany. They, accordingly, state that oil price shocks explain "most of the major movements in the TOT" (Amano and Van Norden, 1998a, p.685). Hence, the real oil price is used as a proxy for exogenous changes in the TOT (Amano and Van Norden, 1998a, p.685).

[30] The interest rate differentials for the US versus Japan, the US versus Germany as well as a weighted measure to capture the construction of the real trade weighted exchange rate are used. The interest rate variable for each country is the difference between the short- and long-run interest rates (Amano and Van Norden, 1998b).

other hand, Amano and Van Norden (1998b) explain that in a model that takes into account that oil prices are global, “higher oil prices will transfer wealth from the oil importers ... to the oil exporter ...” (Amano and Van Norden, 1998b, p.313). The impact on the trade balance and, accordingly, on the US exchange rate depends on the US share of the total exports of industrial countries to OPEC and of their oil imports from OPEC (Amano and Van Norden, 1998b).

Coudert et al. (2008) use the trade-weighted exchange rate of the US dollar provided by the Organization for Economic Co-operation and Development (OECD). They apply cointegration, weak exogeneity and Granger causality tests as well as a vector error correction model (VECM). Their results show a long-run positive relationship between oil prices and the exchange rate that runs from the former to the latter. Moreover, Coudert et al. (2008) study whether the US net foreign assets (NFA) and TOT are transmission variables for this relationship. They find that the exchange rate and NFA are positively cointegrated while the exchange rate and TOT do not cointegrate. As well, the oil price and NFA are positively cointegrated, while the oil price and TOT do not cointegrate. In addition, in a VECM for the US NFA and the oil price, the long-run term in the US NFA equation is significant. Accordingly, Coudert et al. (2008) conclude that an increase in the US NFA, caused by an increase in the oil price, causes the US dollar to appreciate.

Bilateral Exchange Rates Against the US dollar

Chen and Chen (2007) study the existence of a positive long-run relationship between oil prices and the exchange rates of Canada, France, Germany, Italy, Japan, and the UK against the US dollar. Different measures of the real oil price are used: the United Arab Emirates price of oil (Dubai), the British price of oil (Brent), the WTI, and the International Financial Statistics (IFS) world average crude oil price. The US dollar prices of oil are converted into the respective domestic currency and are deflated by the respective domestic CPI. As for the exchange rates, each country’s domestic nominal exchange rate is deflated by its domestic CPI. Chen and Chen (2007) find that exchange rates and oil prices are generally non-stationary, and are cointegrated in the case of Germany and Japan, but are not cointegrated in the case of Canada, France, Italy or the UK. The mixed results are attributed to the lack of power of tests using data for individual countries. Hence, panel analysis is carried out and the results show that exchange rates and oil prices are non-stationary and positively cointegrated.[31]

Chaudhuri and Daniel (1998) study the bilateral exchange rates for 16 OECD countries against the US dollar. The Dubai oil price is the oil price measure used. It is converted from US dollars to the respective currency and deflated by the respective PPI. The exchange rate measures are also deflated by the respective PPI. Chaudhuri and Daniel (1998) argue that when the relative price of oil increases, the price of the output bundle of commodities for an oil producing country increases in comparison to that of non-oil producing countries. This results in an increase in the oil producer's real exchange rate. Chaudhuri and Daniel (1998, p.234) show that the real exchange rate for most industrial countries (except for Canada, Ireland and Spain) and the real price of oil are cointegrated. The cointegration results also show that, after the increase in oil prices in 1978, the real exchange rate experienced long swings away from equilibrium (Chaudhuri and Daniel, 1998, p.237). However, the increase in oil prices in 1986 did not have the same impact in Germany and Japan, which implies there was a change in the response to oil price changes in the global economy.

Employing a VECM, and using both a trade-weighted exchange rate and the US dollar/euro exchange rate, Bénassy-Quéré et al. (2007) find a positive, long-run relationship that goes from oil prices to exchange rates. This empirical finding does not explain the negative relationship that Bénassy-Quéré et al. (2007) observe from visual inspection of the data during 2002-2004.

[31] The increase of the bilateral exchange rate, in this sub-section, means the US dollar appreciates against the currencies of the other sample countries.

2.2.2 Disentangling Oil Price Shocks

There is general agreement that the 2007/2008 oil price shock was due to a surge in global economic growth and demand (Hamilton, 2009; Kilian, 2009a). Hence, it may be important to differentiate between the impact on the exchange rate of a change in oil prices arising from global aggregate demand shocks as opposed to oil supply shocks.

Kilian (2009b) notes that oil prices are driven by distinct demand and supply shocks, and these shocks may have direct effects on the US economy, as well as an indirect effect working through the price of oil. Kilian (2009b) finds it useful to consider the separate effects of oil demand and oil supply shocks for two reasons. First, oil price increases may have very different effects on the real price of oil depending on the underlying cause of the price increase. For example, he finds that “an increase in aggregate demand for all industrial commodities causes a somewhat delayed, but sustained, increase in the real price of oil that is also substantial” (Kilian, 2009b, p.1053), while “crude oil production disruptions cause a small and transitory increase in the real price of oil within the first year” (Kilian, 2009b, p.1053). Second, Kilian (2009b) finds important differences in how the oil demand and oil supply shocks that underlie movements in the real price of oil affect US GDP and the US CPI. For example, an unanticipated oil supply disruption causes mostly no significant impact on the CPI and, if anything, there is evidence of a slight decline in the price level after three years. In contrast, following an unanticipated aggregate demand expansion that raises oil prices, consumer prices show a sustained increase that reaches its maximum in the third year and is statistically significant starting in the third quarter (Kilian, 2009b, p.1060-1067).

Importantly, Kilian (2009b) argues that his findings help explain why regressions of macroeconomic aggregates on oil prices have proven unstable. According to Kilian (2009b), this is because the composition of the demand and supply shocks underlying oil price increases has changed over time, and these shocks exhibit different response patterns (Kilian, 2009b).

In order to examine the composition of the shocks, Kilian (2009b) disentangles the components of an oil shock by applying a 3x3 structural Vector Autoregressive (VAR) model.[32] The three variables in the VAR model are the percent change in global crude oil production, a measure of global economic activity in industrial commodity markets, and the real price of oil. The fluctuations in oil prices, accordingly, are attributed to three structural shocks: an oil-supply disruption shock, a global aggregate demand shock, and an oil-market-specific-demand shock. The latter shock represents the precautionary demand associated with uncertainty regarding oil supply disruptions relative to expected demand (Kilian, 2009b). This shock can be considered to capture any omitted factors. However, Kilian (2009b) asserts that the time of occurrence and direction of such a shock are in harmony with exogenous events that would cause uncertainty about the expected oil supply; for example, the Persian Gulf War in 1990/1991.

Following the same notion as Kilian (2009b), Peersman and Robays (2009) apply a VAR model to study the impact of oil price shocks on the euro area (EA) economy versus the US economy over the period 1986:1-2008:1 (quarterly data). The variables included in their model are grouped into two categories. The first category includes variables that capture supply and demand in the oil market. These variables are world oil production, nominal crude oil prices in US dollars, and world industrial production. The second category includes EA-specific variables. These variables are real GDP, consumer prices, the nominal short-run interest rate, and the euro/US dollar exchange rate. For the US model, the EA variables are replaced by US variables. Hence, there are two vectors of structural shocks. The first is the vector of the three oil price shocks. The second vector includes the EA-specific shocks, or the US-specific shocks.

Regarding the impact of the three structural oil price shocks on the euro/US dollar exchange rate, Peersman and Robays (2009) find the oil-supply disruption shock to be insignificant. A positive aggregate demand shock results in the appreciation of the euro. Similarly, a positive oil-market-specific-demand shock has a significant impact and

[32] The empirical approach follows two steps. The first step is to trace fluctuations in real crude oil prices to different shocks. The second step is to assess empirically the responses of the variable of concern, for example GDP growth, to the different types of shocks. This second step involves calculating the impulse response functions.

causes the appreciation of the euro. According to Peersman and Robays (2009), the oil-market-specific-demand shock captures the incentive to invest in commodities to hedge against the depreciation of the US dollar, which is reflected in the depreciation of the US dollar against the euro that is associated with oil price increases.

With regard to the oil-supply disruption shock that showed the least impact using the Kilian (2009b) approach, Kilian (2008b) develops a series to reflect oil supply disruption shocks due to exogenous political events. He studies the impact of this shock on US real GDP growth and CPI inflation over the period 1973-2005. Empirical analysis shows that the shock explains a small portion of the increase in oil prices in 1973/74, 1990/91 and 2002/03. The counterfactual analysis shows that the shock generally had little impact on US real GDP growth and CPI inflation during the sample period.

Kilian (2008a) uses the methodology developed by Kilian (2008b) to measure exogenous oil supply shocks. Kilian (2008a) utilizes impulse response analysis to study the differences and similarities of the impact of such a shock on macroeconomic factors in the Group of Seven (G-7) countries over the period from 1971 to 2004. As regards the response of each country's nominal dollar exchange rate, the shock results in a significant depreciation of the non-oil-producing G7 countries' currencies. As regards Canada, which is an oil producer, the Canadian dollar appreciates a little in the short run with a marginal level of significance, and depreciates in the long run, but the long-run impact is insignificant (Kilian, 2008a).

2.2.3 Empirical Studies of the Effect of US Government Debt on the US Dollar

In the current chapter, one focus is on empirically studying the impact of US government debt on the US dollar. There are few studies that empirically examine how the US government debt and budget deficit affect the US dollar. This sub-section provides a review of this literature.

McMillin and Koray (1990) apply a VAR model to study the impact of US and Canadian government debt on the real exchange rate of the US dollar against the Canadian dollar from 1963 to 1984, using quarterly data, a sample which includes both fixed and floating exchange rate periods. The model includes data for both the US and Canada, where the variables are calculated as ratios of the US values to the Canadian values. These variables are real gross national product (GNP), the GNP deflator, the nominal AAA corporate bond rate as a measure of the interest rate, nominal M1, real federal government purchases, the nominal market value of privately held government debt, and the real exchange rate. The analysis, based on variance decomposition, shows that the debt variable has a significant impact on the exchange rate. The impulse response function shows that a shock to the ratio of US to Canadian government debt results in a "short-lived" US dollar depreciation (McMillin and Koray, 1990, p.287).[33]

Cayen et al. (2010) utilize a dynamic factor model and state space model to study the factors that drive the long-run movement of the real bilateral exchange rate of the US dollar against the currencies of Australia, Canada, the euro area (EA), Japan, New Zealand and the UK using a panel of quarterly data for 1980-2007. They find "that a deterioration in the US fiscal position" (Cayen, et al., 2010, p.13), as reflected in the government's debt-to-GDP ratio relative to that of the other sample countries, causes a long-run US dollar depreciation on a multilateral level.

Kim and Roubini (2008) apply a VAR model to examine the impact of government budget deficit shocks on the current account and the real exchange rate for the US during 1973–2004 (using quarterly data).[34] The variables included in the basic VAR are the log of real GDP, the ratio of the government budget deficit to GDP, the ratio of the current account to GDP, the three-month (ex-post) real interest rate, and the log of the effective real exchange rate. The model shows that an increase in the government budget deficit results in a US dollar depreciation.

Koray and McMillan (2007) apply a VAR model to study the response of the exchange rate as well as the trade balance to fiscal policy shocks in the US economy

[33] Including the US and Canadian government three-month Treasury bill rates in place of the nominal AAA corporate bond rate to model the short-run effect of the interest rate rather than the long-run effect, McMillin and Koray (1990) find that the results do not differ.

[34] Kim and Roubini (2008) use the real price-adjusted major dollar index provided by the Federal Reserve. This index is computed using data on the euro, British pound, Swedish korona, Swiss franc, Australian dollar, Japanese yen and Canadian dollar (Federal Reserve, 2005).

over the period 1980-2005 (using quarterly data). The variables included in the VAR are the price level, real government purchases, output, the real long-term interest rate, real net taxes, the real exchange rate, and the trade balance. The results show that a positive shock to government purchases causes a persistent increase in the budget deficit, a drop in interest rates, a US dollar depreciation, and an improvement in the trade balance. The same results are associated with a negative shock to net taxes, yet the results are insignificant.[35]

Muller (2004) applies a VAR model to the US for the period 1973-2003, using quarterly data. The variables included are the log of real government spending per capita, the log of real GDP per capita, the log of the GDP deflator, the log of the nominal exchange rate, the log of the terms of trade (TOT), and the trade balance. The results show that a temporary positive shock in government spending causes the currency to depreciate, the trade balance to improve, and the TOT to appreciate.[36]

Clarida and Prendergast (1999) apply a VAR model to study the dynamic relationship between fiscal policy and the exchange rate in the US, Japan and Germany over the post-Bretton Woods period. The four variables used for each country are the ratio of the OECD estimate of the structural primary budget surplus to potential GDP, the OECD estimated output gap, the ratio of the actual primary budget surplus to actual GDP, and the trade-weighted exchange rate. The exchange rate variable is a "forward looking asset price" (Clarida and Prendergast, 1999, p.5) that changes in response to innovations in the supply and demand for "national output" (Clarida and Prendergast, 1999, p.5). Hence, the exchange rate variable is ordered last to allow it to respond to contemporaneous shocks in both fiscal and business cycle variables. The estimates show that fiscal cycles have a significant role in driving exchange rate movements. The

[35] The ordering allows for the existence of the contemporaneous impact of fiscal policy, prices, output and interest rate on the exchange rate. Koray and McMillan (2007) use the real trade-weighted exchange rate for the US.

[36] Government spending is assumed to not respond in a contemporaneous manner to movements in the other five variables (Muller, 2004). Hence, the government spending variable is required to be ordered first for government spending to be identified as an exogenous shock with respect to the other variables. The robustness of the results was checked by adding variables to the VAR (Muller, 2004). These included the 10-year nominal interest rate, a net taxes variable, and public spending deflated by the GDP deflator rather than "its own deflator." As well, the real exchange rate was replaced by the nominal interest rate (Muller, 2004).

exchange rate in each of the US, Japan and Germany appreciates in response to expansionary fiscal policy and then depreciates to a level that is less than that prevailing before the fiscal shock (Clarida and Prendergast, 1999).[37]

2.2.4 More Empirical Studies of the Exchange Rate

2.2.4.1 Empirical Studies of Macroeconomic Factors and Exchange Rates

2.2.4.1.1 Relative Prices

Taylor and Taylor (2004) and Rogoff (1996) provide a review of the work done on the purchasing power parity (PPP) theory[38]. They conclude that real exchange rates converge to PPP in the "very long run," and can show large and volatile deviations from PPP in the short run (Rogoff, 1996, p.647).

After the end of the Bretton Woods period, the monetary approach to modelling exchange rate movements was the "dominant approach" and assumed PPP held continuously (Taylor and Taylor, 2004, p.141). According to this approach, the exchange rate is the relative price of money in two economies. Therefore, the relative price is dependent on supply and demand in each country's money market "in an asset market equilibrium" (Taylor and Taylor, 2004, p.141). Taylor and Taylor (2004) attribute the encouraging results of the empirical studies on the monetary approach that were conducted in the 1970s to the relative stability of the US dollar in the initial stages after its flotation. By the end of the 1970s, however, the volatility of the US dollar increased, resulting in the rejection of PPP.

Rogoff (1996) states that the long-run deviations of the exchange rate from PPP are explained by real factors, such as cumulated current account deficits and government spending. Rogoff's (1996) interpretation of Krugman's (1990) findings is that the current account has a significant impact on movements in the real exchange rate because it

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[37] An expansionary fiscal policy that causes aggregate demand to increase is expected to cause the exchange rate to appreciate. The reason is that such an increase in aggregate demand causes the price of domestic output to increase relative to that of foreign output, increasing the relative prices of non-tradables in the domestic country. The foreign exchange rate market expects the fiscal expansion to be followed by fiscal contraction. The reason is that, following the government's intertemporal budget constraint, the present value of taxes is constant (Clarida and Prendergast, 1999).

[38] According to Taylor and Taylor (2004, p.135), the PPP theory is valid when "the nominal exchange rate between two currencies should be equal to the ratio of aggregate price levels between the two countries, so that a unit of currency of one country will have the same purchasing power in a foreign country."

causes wealth movements across countries. Regarding government spending, Rogoff (1996) reports that Froot and Rogoff (1991) find that this variable has a significant impact on real exchange rates in European Monetary System (EMS) countries, and that Alesina and Perotti (1995) observed that a fiscal policy that involves a distortionary tax to finance government spending has an impact on the real exchange rate.

2.2.4.1.2 The Uncovered Interest Rate Parity Approach

The Uncovered Interest Rate Parity (UIP) approach indicates that the expected relative change in the exchange rate is equal to the interest rate differential between two countries. The following equation represents the UIP condition:

$$S_{t+k}^{e} - S_t = \beta \hat{\imath}_t^k, \qquad 1$$

where $\hat{\imath}_t^k$ is the interest rate differential of assets with maturity k. The variable S_{t+k}^{e} is the forward expected exchange rate and S_t is the spot exchange rate. The coefficient on the interest rate differential, β, must be one for UIP to hold (Alquist and Chinn, 2008), so

$$S_{t+k}^{e} - S_t = \hat{\imath}_t^k. \qquad 2$$

Froot and Thaler (1990), Chinn and Meredith (2004b), Alquist and Chinn (2008), Huisman et al. (2007), and Chaboud and Wright (2005) study the UIP approach in modelling exchange rates. The general finding is that the UIP holds in the long run rather than in the short run because of the temporary shocks to exchange rates that appear in the short run. The UIP condition is valid when the temporary short-run shocks are filtered out via focusing on the long run or using discrete high-frequency data. In the short run, UIP does not hold because monetary policy responds to shocks in the exchange rate, causing a negative correlation between the exchange rate and interest rates. In the long run, however, the movements in exchange rates and interest rates are governed by macroeconomic fundamentals and hence are more consistent with the UIP hypothesis (Chinn and Meredith, 2004b). The UIP condition is valid in the case of discrete high-frequency data because the risk premium tends to zero with sufficiently small time intervals (Chaboud and Wright, 2005).

2.2.4.1.3 Monetary Approach

Alquist and Chinn (2008) provide the following generic equation for the monetary approach to modelling exchange rates:

$$S_t = \beta_0 + \beta_1 \hat{m}_t + \beta_2 \hat{y}_t + \beta_3 \hat{\imath}_t + \beta_4 \hat{\pi}_t + u_t. \qquad 3$$

Where ^ indicates the inter-country differentials for the log of money (m_t), the log of the real GDP (y_t), the interest rate (i_t), and the inflation rate (π_t). The variable S_t is the log of the exchange rate.

Meese and Rogoff (1983), Alquist and Chinn (2008), Engel, Mark and West (2007), and Rogoff and Stavrakeva (2008) study the monetary approach in modelling exchange rates. The general finding of Meese and Rogoff (1983), Alquist and Chinn (2008) and Engel, Mark and West (2007) is that, although monetary models tend to do well in explaining exchange rates in the long run, they generally perform only as well as a random walk model in the short run. While Meese and Rogoff (1983) do not employ oil prices in their analysis, they conjecture that structural instability, due to oil price shocks and changes in macroeconomic policy regimes, may be important to explaining why they find structural models do not out-forecast the random walk model.

Engel, Mark and West (2007) apply panel techniques and find a limited ability to forecast short-run changes in the exchange rate using the monetary model. However, Rogoff and Stavrakeva (2008) state that the results are optimistic due to the dependence on asymptotic tests and the failure to test the robustness of the estimates by comparing them to other models. Also, the results differ from one period to another. That is, they outperform a random walk in one period and not in another (Rogoff and Stavrakeva, 2008).

2.2.4.1.4 External Imbalances Approach

Gourinchas and Rey (2007) apply an intertemporal approach to study the impact of revaluation of Net Foreign Assets (NFA) on external adjustment for the US economy. In their model, the exchange rate is a function of a derived external imbalances variable, which is the sum of the expected present value of growth of net exports (trade channel) and the expected present value of returns on NFA (valuation channel). They find that their exchange-rate model outperforms a random walk, and can explain short- and long-run exchange rate movements. Using a comparable measure of external imbalances, Alquist and Chinn (2008) show that this approach does not outperform a random walk for the yen in the long run, but outperforms a random walk for the euro and the Canadian dollar in the short run. Alquist and Chinn (2008) state that their results differ from those of Gourinchas and Rey (2007), as Gourinchas and Rey (2007) use a longer time series and multilateral exchange rates, while Alquist and Chinn (2008) use bilateral exchange rates.

2.2.4.1.5 More Macroeconomic Factors

In related literature, Frankel and Rose (1996) use a multivariate probit model to analyse data for 105 developing countries over the 1971-1992 period to study the determinants of currency crashes. Frankel and Rose (1996) show that government budget deficits have an insignificant role in the occurrence of currency crashes which take place when FDI inflows become low, the growth of domestic credit elevates, foreign interest rates increase, and the exchange rate is overvalued.

2.2.4.2 Empirical Studies of Exchange Rates and Commodity Prices

Cashin et al. (2004) study 53 developing countries and five industrial countries[39] for which commodity exports are a significant source of export income during January 1980 and March 2002, to examine how many of these "commodity-exporting countries have commodity currencies" (Cashin et al., 2004, p. 241). These would be the currencies of the countries for which the movement in the real exchange rate is explained by movements in commodity prices. The effective real exchange rate of each country is the exchange rate measure used. The real price of commodity exports is the nominal price of commodity exports deflated by the International Monetary Fund's (IMF) price index of manufactured exports. Standard cointegration tests show that the real exchange rate and real commodity prices are cointegrated. When applying cointegration tests that allow

[39] Australia, Canada, Iceland, Norway and New Zealand.

for structural shifts, the general finding is that in one-third of the sample countries, movements in world real commodity prices explain movements in each country's real exchange rate. Applying weak exogeneity tests, it is found that causality goes from commodity prices to real exchange rates. Cashin et al. (2004) conclude that changes in real commodity prices significantly explain the "long run deviations of the real exchange rates from PPP" and cause the "long-run real exchange rate of commodity currencies" to be time varying (Cashin et al., 2004, p.241).

Bayoumi et al. (2005) estimate a panel dynamic ordinary least squares (panel DOLS) model to study the determinants of manufacturing-output-deflator-based real effective exchange rates for 10 industrial countries[40]. They find that net foreign assets (NFA) and commodity prices are generally significant long-run determinants of the exchange rate variable. Bayoumi and Muhleisen (2006) show, using an Error Correction Model (ECM), that energy and non-energy commodities significantly affect the exchange rate. As well, the interest rate differential is significant, indicating that an increase in the interest rate differential causes the Canadian dollar to appreciate against the US dollar.

2.2.5 Summary of the Empirical Literature

Amano and Van Norden (1998a and 1998b), Chaudhuri and Daniel (1998), Chen and Chen (2007), Coudert et al. (2008), and Bénassy-Quéré et al. (2007) empirically study the impact of oil price changes on exchange rate movements. All these studies apply time series techniques using monthly data over the post-Bretton Woods period for mostly oil importing countries. The general results of these empirical studies are that oil prices and exchange rates are non-stationary, and that there exists a stable positive relationship between the two variables in the long run, in which an increase in oil prices causes the US dollar to appreciate. The short-run impact of an increase in oil prices on US dollar movements, however, is generally insignificant. In addition to the general findings mentioned above, Amano and Van Norden (1998b) find that real interest rate

[40] The 10 countries are Australia, Canada, Denmark, the Euro Area, Japan, Norway, New Zealand, Sweden, the UK, and the US.

differentials add no significant explanation to short- and long-run changes in exchange rates. Coudert et al. (2008) find that an improvement in the US NFA position, which is caused by an increase in the oil price, leads to an appreciation of the US dollar. Accordingly, they conclude that US net foreign assets (NFA) is a transmission variable between the oil price and the US dollar.

In addition to the empirical studies that apply cointegration, ECM, VECM and VAR techniques, Cayen et al. (2010) apply a dynamic factor model and a state space model to study the impact of changes in commodity prices, accounting for changes in oil prices and non-energy commodity prices, and changes in government debt on the US dollar. They find the presence of a long-run relationship between oil prices and real exchange rates.

According to VAR models applied by Kilian (2009b) and Peersman and Robays (2009) to disentangle oil price shocks, it is important to examine the impact of the demand and supply shocks underlying oil price movements. When disentangling oil price shocks, it is found that a global aggregate demand shock results in a persistent increase in oil prices. As for the impact on the exchange rate, positive demand shocks cause the US dollar to depreciate against the euro whereas an oil supply shock does not have a significant impact.

As for the role of government debt as a determinant of exchange rate changes, McMillin and Koray (1990) and Cayen et al. (2010) find that an increase in government debt causes the US dollar to depreciate. Kim and Roubini (2008), Koray and McMillan (2007) and Muller (2004) show that an increase in the budget deficit causes the US dollar to depreciate. Clarida and Prendergast (1999) show that an expansionary fiscal policy causes exchange rate appreciation followed by depreciation.

Only Cayen et al. (2010) examine the impact of changes in both the government debt and the oil price on the US dollar, but they study only the long-run effects. Otherwise, the empirical literature on the US dollar and oil prices does not account for changes in the supply of US assets, and the empirical literature on the US dollar and supply of US assets does not incorporate oil prices.

The empirical literature which examines exchange rates accounting for neither oil prices nor government debt includes the literature on relative prices (PPP), UIP, monetary policy and the external imbalances approach to modelling and forecasting exchange rates, as well as the literature on exchange rates and commodity prices. This literature shows that the long-run deviations of the exchange rate from PPP can be explained by real factors such as government spending. The UIP condition is valid when focusing on the long run or using discrete high-frequency data. Monetary models generally perform only as well as a random walk model in the short run, which according to Meese and Rogoff (1983) could be attributed to structural instability due to oil price shocks and changes in macroeconomic policy regimes. The external imbalances approach of Gourinchas and Rey (2007), based on an external imbalances variable that incorporates NFA, can explain short- and long-run exchange rate movements. In studying the occurrence of currency crashes that are associated with high foreign interest rates, for example, Frankel and Rose (1996) show that government budget deficits have an insignificant role. The empirical literature on exchange rates and commodity prices shows that the NFA position, interest rate differentials, and energy and non-energy commodity prices are generally significant.

3 The Hypotheses Examined

The objective of this chapter is to use the portfolio balance model developed in Chapter One to study empirically the role of oil prices and government debt as determinants of movements in the US dollar in a dynamic framework. An error correction model (ECM) is employed to jointly study the impact of changes in oil prices and government debt on US dollar movements. As described above, theoretical portfolio balance models predict that a rise in the oil price is likely to lead to a fall in the value of the US dollar in the long run, but in the short run the US dollar could appreciate if oil exporters have a high preference for US dollar-denominated assets. The index developed by Kilian (2009b) is utilized to separate demand and supply shocks underlying oil price movements. This is done because the composition of these shocks changes over time, which may make it difficult to identify a systematic relationship between movements in oil prices and the US dollar. As noted above, the general finding of the theoretical portfolio balance model literature is that a rise in US government debt is expected to lead to a US dollar depreciation in the long run and the short run, although in Chapter One – akin to Bernanke's (2005b) case in which wealth does not affect consumption – I find no effect in the long run.

Other variables are added to the model to check the robustness of the findings. The additional variables that are in line with the literature, as discussed in sub-section 2.2, are the US NFA-to-GDP ratio and the interest rate differential. Further additional variables that are not studied by the previous literature and are included in the robustness sub-section are variables that capture the impact of the risk in the US financial market and of China's entry into world trade.

An ECM is used so that both short- and long-run effects can be estimated, since the theoretical literature suggests that these effects may differ. It is important to emphasize that the objective of this chapter is to study the determinants of US dollar movements rather than to forecast these movements.

In summary, the hypotheses examined can be presented by the following equation:

ER_t = f(*demand and supply shocks underlying oil price changes, US government debt, other variables*) 4

where ER_t is the US exchange rate.

4 Empirical Methodology

In what follows, an ECM is applied to study the short- and long-run effects of changes in the real price of oil, accounting for the source of oil price changes, and government debt on US dollar movements. The first two sub-sections provide an overview of the autoregressive distributed lag model (ARDL)/ECM methodology and its advantages. Sub-section 4.3 discusses the disaggregation of the demand and supply components of oil price changes, following a methodology motivated by Kilian (2009b).

4.1 Advantages of the Error Correction Model

An advantage of the ECM methodology is that it allows the identification of the short- and long-run effects of the explanatory variables as well as the speed of adjustment toward the long-run equilibrium. This is important because portfolio balance models suggest that the short- and long-run effects may differ.

The ECM is derived from an ARDL model and can be estimated using OLS. OLS estimation of an ARDL model yields consistent results if all variables are stationary, or nonstationary, or only some variables are stationary. In other words, testing for stationarity of the variables is not a requirement when there is a long-run relationship between the dependent and explanatory variables (Pesaran and Shin, 1998). This is especially beneficial given the possible nonstationary nature of oil prices.

4.2 Derivation and Linear Estimation of the Error Correction Mechanism

Following Pesaran and Shin (1998), a two-step-strategy, referred to as the autoregressive distributed lag-Schwartz Bayesian Criterion (ARDL-SC), is applied to estimate the ECM. The first step involves applying the Schwartz Information Criterion (SIC) to decide on the number of lags to be included in the ARDL model.[41] In order to allow for up to 12 lags with quarterly data, 12 OLS regressions are estimated for ARDL(i, i); i =1,2,....,12, where i is the number of lags. The model is represented as follows:

$$\Delta ER_t = \alpha ER_{t-i} + \sum_{i=2}^{12} \gamma_{i-1} \Delta ER_{t-i+1} + \sum_{i=1}^{12} \theta_i \Delta X_{t-i+1} + \theta_{i+1} X_{t-i} + \theta_0 + \varepsilon_t. \quad 5$$

where ΔER_t is the change in the log of the exchange rate, and X_t is the vector of explanatory variables.

[41] According to Pesaran and Shin (1998) simulation results, a two-step strategy that involves the usage of SIC is better than that using the Akaike Information Criterion (AIC). Therefore, ARDL-SC is "slightly better" (Pesaran and Shin, 1998, p. 374) than ARDL-AIC which is in accordance with the fact that "SC is a consistent model-selection criterion, while AIC is not" (Pesaran and Shin, 1998, p. 374).

The second step is to estimate the short-run and long-run coefficients and their standard errors from the ARDL. Using an ARDL with one lag, (ARDL (1,1)), without loss of generality, the process of deriving the short-run and long-run coefficients of the ECM from the ARDL uses the following equation:

$$ER_t = \lambda_1 ER_{t-1} + \beta_1 X_t + \beta_2 X_{t-1} + \beta_0 + \varepsilon_t. \qquad 6$$

Subtract ER_{t-1} from both sides, and add and subtract $\beta_1 X_{t-1}$ to and from the right hand side:

$$\Delta ER_t = (\lambda_1 - 1)ER_{t-1} + \beta_1 \Delta X_t + (\beta_1 + \beta_2)X_{t-1} + \beta_0 + \varepsilon_t, \qquad 7$$

$$\Delta ER_t = \beta_0 + \beta_1 \Delta X_t + (\lambda_1 - 1)[ER_{t-1} - \frac{(\beta_1+\beta_2)}{1-\lambda_1} X_{t-1}] + \varepsilon_t. \qquad 8$$

Equation (8) represents the ECM. In equation (8), $(\lambda_1 - 1)$ represents the adjustment term, β_1 represents the short-run marginal impact of a change in an explanatory variable on the exchange rate, and the term $\frac{\beta_1+\beta_2}{1-\lambda_1}$ represents the long-run marginal impact. The long-run relationship between the exchange rate and explanatory variables is represented by the term $[ER_{t-1} - \frac{\beta_1+\beta_2}{1-\lambda_1} X_{t-1}]$. Equation (7), which can be re-stated as follows, is estimated via OLS:

$$\Delta ER_t = \alpha ER_{t-1} + \theta_1 \Delta X_t + \theta_2 X_{t-1} + \theta_0 + \varepsilon_t. \qquad 9$$

The adjustment term $(\lambda_1 - 1)$ in equation (8) is equivalent to the adjustment term α in equation (9). Similarly, the short-run marginal effect of X_t on ER_t is β_1 in equation (8) and θ_1 in equation (9) where $\beta_1 = \theta_1$, and the long-run effect is $\frac{\beta_1+\beta_2}{1-\lambda_1}$ in equation (8) and $-\frac{\theta_2}{\alpha}$ in equation (9) where $\frac{\beta_1+\beta_2}{1-\lambda_1} = -\frac{\theta_2}{\alpha}$.

Pesaran and Smith (1998) show that standard inference can be carried out on the short- and long-run parameters even if it is not known a priori which variables are I(0) and which are I(1). On the other hand, Pesaran et al. (2001) show that the coefficient on the lagged dependent variable – the adjustment term – in an ECM does not have a standard t-distribution. Pesaran et al. (2001) develop a "bounds test" for the significance of the adjustment term. This test is valid whether the variables in levels are I(0) or I(1), and is a means to test for the existence of a long-run relationship. The bounds test involves testing for the exclusion of the lagged dependent variable, which is the null hypothesis, versus the existence of a level relationship between the dependent variable and the explanatory variables, i.e. the presence of cointegration. The asymptotic critical values of the test represent upper and lower critical value bounds. If the t-statistic associated with the adjustment term lies between the two bounds, inference is inconclusive and knowledge of the order of integration of the variables is required for a conclusive inference. If the t-statistic associated with the adjustment term lies below the lower bound, the null hypothesis of no cointegration cannot be rejected. And, if the t-statistic associated with the adjustment term is above the upper bound, the null hypothesis of no cointegration is rejected.

4.3 The Demand and Supply Components of Oil Price Changes

Kilian (2009a) states that the engine behind the atypical 2007/08 oil price shock was the increase in global real economic activity. In this sub-section, the underlying components of oil price changes are separated into a global aggregate demand shock, and all-other-effects shock, which Kilian (2009b) further separates into an oil supply disruption shock and a precautionary demand shock. The target of this chapter is to study the effects of the global aggregate demand shock and all-other-effects shock as well as the effect of government debt on US dollar movements. For this purpose, the residuals and predicted values are retrieved from a simple OLS model in which the log of the real price of oil is regressed on KI – the global aggregate demand variable – and a constant. The time sample used for this regression is 1986:1-2010:4, quarterly data.[42] The predicted values from this regression represent the movements in the oil price driven only by changes in global aggregate demand, referred to hereafter as the global-aggregate-demand oil-price effect. The residuals capture the movements in the oil price that are not explained by changes in global aggregate demand. The residuals instead

[42] The time sample is discussed and an overview of the variables used is provided in the Data section that follows.

reflect changes in the price of oil due to oil supply changes and other demand shocks which Kilian (2009b) calls precautionary oil demand shocks. The residuals are referred to, hereafter, as the oil-supply-and-precautionary-demand oil-price effect.

Figure 2-1 shows the real price of oil in log terms along with the two oil price effects underlying oil price changes: the global-aggregate-demand oil-price effect and the oil-supply-and-precautionary-demand oil-price effect. Oil price movements have been attributed in the literature to changes in oil production caused by exogenous political events. However, when disentangling oil price movements, Kilian (2009b) finds that oil price demand shocks are the primary cause of oil price changes, and that the oil supply disruption effect is short lived and generally insignificant. The oil-supply-and-precautionary-demand oil-price effect derived from the abovementioned OLS regression reflects the changes in oil production and market expectations regarding oil production. Market expectations regarding oil production capture the precautionary-demand oil-price effect which, as explained by Kilian (2009b), reflects uncertainty in oil production relative to the expected demand for oil. Kilian (2009b) states that exogenous factors, such as wars and crises, affect the price of oil mainly through the precautionary demand for oil. This is because uncertainty about future oil production will probably immediately affect oil prices when oil production has not changed.[43] When carrying out an OLS regression where the log of the real price of oil is regressed on KI and the percentage change in crude oil production, the residuals and predicted values are quite similar to those retrieved from the OLS model, which does not include the percentage change in production[44]. This means that the predicted values are driven mainly by KI and the residuals are driven mainly by precautionary demand.

Historical events can be traced to further clarify the link between the two oil price effects underlying oil price changes. Figure 2-1 shows that the spike in the price of oil in 1990, in the aftermath of the invasion of Kuwait, is captured by the oil-supply-and-

[43] For details on the definition of the disentangled oil price shocks, refer to Kilian (2009b), Peersman and Robays (2009), and section 2.2.2 above.
[44] The results from the OLS model that includes the percentage change in production are available from the author.

precautionary-demand oil-price effect and not by the global-aggregate-demand oil-price effect. The increase in oil prices in the early 2000s, which was mainly driven by the increase in global economic activity is captured, as shown in Figure 2-1, by the increase in the global-aggregate-demand oil-price effect and the decrease in the oil-supply-and-precautionary-demand oil-price effect. Also, Figure 2-1 shows that the oil-supply-and-precautionary-demand oil-price effect increased while the global-aggregate-demand oil-price effect dropped during late 2008. This period coincides with the collapse in global economic demand and the second phase of the US financial crisis.

The correlation between the oil price variable and the global-aggregate-demand oil-price effect is around 0.75, whereas the correlation between the two oil price components is zero by construction. The retrieved residuals and predicted values, and their lagged values, are incorporated in the ECM along with the ratio of the US federal debt held by the public to GDP. The results are discussed in Section 6.

5 Data

In the first sub-section below, the time period to be studied is established and its selection is discussed. The second sub-section describes the variables used in the estimation.

5.1 Time Period

The time period studied in this chapter is 1986:1 to 2010:4 (quarterly data). The model is also estimated for the period 1986:1 to 2007:2 in an effort to exclude the data associated with the recent US financial crisis.

In the current research, the period studied is different from most existing studies in that it extends the sample to include the 2007/2008 shocks, and excludes the 1970s and early 1980s. The only exception is Peersman and Robays (2009), who study the period 1986 to 2008 using quarterly data. The reason for excluding the early period is that both the oil market and the exchange rate market were subject to significant changes in the mid-1980s.

Regarding the oil market, Peersman and Robays (2009) break the sample in

1986 since the year 1986 is closely related to the collapse of the OPEC cartel and is often selected in the oil literature to signify structural breaks in the oil market[45]. Also, Peersman and Robays (2009) argue there is a break in oil market dynamics in the first quarter of 1986, after which the dynamics remain stable.

As for the foreign currency market, the group of five (G-5) countries (France, West Germany, Japan, the US and the UK) reached the Plaza agreement in September 1985 to decrease the value of the US dollar against major foreign currencies. The adjustment in the value of the US dollar, accordingly, took place through coordinated sales of dollars (Mishkin, 1997). By the beginning of 1987, the US dollar had decreased in value, on average, by 35% relative to the other currencies (Mishkin, 1997).

In light of the structural breaks in the oil and foreign currency markets in the mid-1980s, and following Peersman and Robays (2009), the time period studied in this chapter starts in 1986. The period is extended to cover the recent global economic crisis and substantial increase in oil prices in the 2000s. The first stage of the US financial crisis started in July 2007 as noted by Caballero et al. (2008); hence, this period is included in the empirical analysis.

5.2 Variables

I choose the variables to include in the empirical exchange-rate model based on the theories discussed in Chapter One. The variables used in the robustness tests are based on the alternative theoretical explanation described in the literature review. Some of these additional variables are variables that other studies have found to be important. An overview of the variables used in the benchmark model is presented in this sub-section. Data sources for these variables and the additional variables used for the

[45] Griffin and Neilson (1994) argue that the pricing strategy of oil in the 1970s and early 1980s is different. In March 1983, OPEC decided on a monthly production quota for its members. Saudi Arabia enforced the cartel cohesion via a “swing producer” strategy to adjust output and stabilize oil prices during the period 1983:03 to 1985:08. Afterwards, Saudi Arabia followed a “tit-for-tat” strategy. In the case of the “swing producer” strategy, a stable oil price is expected because a decline in Saudi production below its quota is expected when others cheat. In other words, Saudi Arabia adjusts its oil production to stabilize oil prices. In the case of the “tit-for-tat” strategy, one would expect more oil-price variation because Saudi Arabia is not making an effort to stabilize oil prices; instead, to maintain its market share, Saudi Arabia matches cheating by other members.

robustness tests are provided in Appendix 2-1. An overview of the additional variables is presented in Appendix 2-2.

5.2.1 Exchange Rate

An effective (trade-weighted) exchange rate index can be used to summarize a set of divergent changes in bilateral exchange rates. This is an attractive measure for the US dollar exchange rate because no single bilateral exchange rate can adequately capture the movement in the US dollar (Pauls and Helkie, 1987). The real price-adjusted broad dollar index is the real trade-weighted exchange rate measure used in this research. The Federal Reserve Bank provides monthly data for this variable. Details on the construction of the index are in Appendix 2-1. I convert the monthly exchange rate data, as well as all other monthly data, to a quarterly frequency by averaging the monthly data.

In general, the real effective exchange rate reflects the level of competitiveness of domestic goods relative to foreign goods, and the demand for domestic assets relative to foreign assets (Van Marrewijk, 2007). The US real price-adjusted broad dollar index is more informative than the nominal index of the level of US trade competiveness when inflation in non-US countries is significantly different from that in the US (Federal Reserve, 2005).

5.2.2 Real Price of Oil and its Components

Different oil prices exist. Figure 2-2 shows that the daily data for three different measures of crude oil prices – WTI, Brent and Dubai – all move together during the sample, 1986-2010.[46] The correlation between the daily data for these three oil prices is 0.99 between 29 January 1986 and 31 December 2010.[47] The WTI price is chosen for this study. The daily data for the WTI price are graphed in Figure 2-3. The real average monthly WTI oil price and the real exchange rate are illustrated in Figures 2-4 and 2-5, where the monthly average spot oil price is deflated by the US CPI.

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[46] The link between WTI and Brent has broken down in 2011.
[47] The starting date used to calculate the correlation between the oil price measures is based on data availability as pointed out in Appendix 2-1.

As described in Section 4.3, to examine how the individual components of the price of oil affect the exchange rate, residuals and predicted values are retrieved from an OLS regression of the price of oil on the global aggregate demand variable – the Kilian index (KI) – and a constant. The predicted values from the regression represent movements in the price of oil due to changes in global aggregate demand, referred to as the global-aggregate-demand oil-price effect. The residuals capture the movements due to other factors, called the oil-supply-disruption-and-precautionary-demand oil-price effect. Coefficient estimates on the remaining variables in the regression equation will be the same whether the regression equation includes the price of oil and the global-aggregate-demand oil-price effect, or the global-aggregate-demand oil-price effect and the oil-supply-disruption-and-precautionary-demand oil-price effect. To facilitate the interpretation of the contribution of these two factors, the global-aggregate-demand oil-price effect and the oil-supply-disruption-and-precautionary-demand oil-price effect are used.

The decomposition of the oil price into two parts uses the index generated by Kilian (2009b), referred to as the Kilian Index (KI). Kilian (2009b) created this index of global economic activity from information on representative single voyage freight rates for bulk dry cargoes collected by Drewry Shipping Consultants Ltd. Examples of bulk dry cargoes are coal, iron ore, fertilizer and scrap metal.

The Kilian (2009b) index is measured at a monthly frequency and goes back to January 1968. To construct the index, Kilian (2009b) takes simple averages of the freight rates and eliminates the fixed effects for different routes, commodities and ship sizes. The latter step requires computing the period-to-period growth rates for each series as far as data are available, taking an equal-weighted average of these growth rates, normalizing the value of the KI in January 1968 to unity, cumulating the average growth rates based on the normalization in January 1968, deflating the series with the US CPI and, finally, detrending the real index.

Another monthly index on global real economic activity that can be used, as noted by Kilian (2009b), is the OECD index of industrial production. Kilian (2009b), however, states that the advantage of KI is that it captures the recent surge in demand for industrial commodities by emerging economies such as China and India. Figure 2-6 depicts KI along with the real WTI oil price and real exchange rate.[48]

5.2.3 The Ratio of the US Federal Debt Held by the Public to GDP

The federal debt held by the public, the measure used in this study to represent the federal debt, is federal debt held by individuals, corporations, state or local governments, foreign governments, and other non-US government entities, excluding Federal Financing Bank (FFB) securities.[49] The ratio of the federal debt held by the public to GDP and the real exchange rate are illustrated in Figure 2-7. The GDP and federal debt held by the public data are available on a quarterly basis, which restricts the frequency of the sample used to obtain the estimates to a quarterly frequency.[50]

6 Results

This section discusses the results of the estimation of the ECM in which the demand and supply components of oil price changes and the ratio of the US federal debt held by the public to GDP are explanatory variables for the real US dollar exchange rate. As well, additional empirical analyses are carried out in the following section to check the robustness of the results. For instance, because the relationship between the US dollar and oil prices may be bi-directional, tests for exogeneity and Granger causality are undertaken in the "Robustness" sub-section.

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[48] According to Kilian (2009b), periods of highest real global economic activity are 1970-1971 and 1972-1975. The periods of sustained high real global economic activity are 1978-1981 and post 2002, where the latter period experienced a more persistent shock.

[49] The public debt is the sum of the debt held by the public and intra-governmental holdings. The "Intragovernmental Holdings are Government Account Series securities held by Government trust funds, revolving funds, and special funds; and Federal Financing Bank securities" (http://www.treasurydirect.gov/govt/resources/faq/faq_publicdebt.htm). The FFB securities are issued by the FFB to the public in order to finance its obligations. The FFB was established "to consolidate and reduce the government's cost of financing a variety of federal agencies and other borrowers whose obligations are guaranteed by the federal government" (http://www.treasurydirect.gov/govt/resources/faq/faq_publicdebt.htm). For that reason, the FFB issues obligations to the public to finance its operations up to a limit of $15 billion except if the Appropriations Acts permit otherwise (http://www.treasurydirect.gov/govt/resources/faq/faq_publicdebt.htm).

[50] The debt variable does not include Treasury debt held by the Federal Reserve. If these liabilities are included in the debt variable, the debt variable becomes insignificant in the long run. Theoretical considerations suggest debt held by the public may be the more appropriate variable.

6.1 The Impact of the US Federal Debt and the Demand and Supply Components of Oil Price Changes on the US Dollar

The model represented by equation (9) in the "Methodology" section is estimated where the vector of explanatory variables X_t contains the global-aggregate-demand oil-price effect, oil-supply-and-precautionary-demand oil-price effect, and the ratio of the US federal debt held by the public to GDP. The ARDL model is initially estimated using quarterly data allowing for up to 12 lags. The Schwartz Information Criterion (SIC) is used to decide on the number of lags for the ARDL. The ARDL model with one lag for the dependent and explanatory variables is the model that has the smallest value for the SIC and, hence, is chosen as being most appropriate. The results of the ECM are reported in Table 2-1.

The estimates that use data for the period 1986:1-2007:2, which excludes the recent financial crisis, are discussed first. From the bounds test, the adjustment term is significant, indicating the presence of a long-run relationship between the US dollar, the ratio of the US federal debt held by the public to GDP, and the components underlying oil price changes. As for the short- and long-run effects, the US federal-debt-held-by-the-public-to-GDP ratio has a significant negative (implying depreciation) effect in both the short and long run. The components of the oil price changes are also both significant and negative in the short and long run. The two types of oil price changes have statistically different effects on the US dollar in both the short run and the long run at a 10% significance level.[51] The results show a negative relationship between the oil price and the US dollar whether the cause of the movement in oil prices is a global aggregate demand shock or an oil supply and precautionary demand shock.[52]

[51] For the hypothesis regarding whether the two oil price components are statistically equal, results for the F-tests are $F(1, 78) = 3.15$ for the short-run impact and $F(1, 78) = 3.61$ for the long-run impact.

[52] In an earlier version of this chapter, the robustness of the results regarding the impact of the demand and supply components of oil prices changes – derived using the OLS model – on the US dollar is checked using the Kilian (2009b) VAR approach, and monthly data for the period January 1986 to December 2010:4. According to the Kilian (2009b) VAR approach, oil price movements are disentangled into an oil supply disruption shock, a global aggregate demand shock and a precautionary demand shock. The impulse response functions show that the oil-supply disruption shock has an insignificant impact. The global aggregate demand shock has a negative impact on the exchange rate variable, which is generally significant until the sixth month. The precautionary demand shock has a negative and generally significant impact until the fourth month. In

As noted above, Kilian (2009b) argues that oil prices are driven by distinct demand and supply shocks. These shocks may directly affect other macroeconomic variables. This might explain why the global aggregate demand shock has a larger impact on the exchange rate than the oil supply and precautionary demand shock. The global-aggregate-demand oil-price effect may be capturing not only a direct impact on the oil price, but also the effect of positive shocks to the world's demand for assets. This would be consistent with the observed negative correlation between the US dollar and the return on US equities, which has been documented by Campbell et al. (2010). They conjecture that this correlation may be due to investors' preferences for US dollar-denominated assets in times of economic downturns arising from a flight-to-quality effect. In a contraction, this flight-to-quality would cause the US dollar to rise in value which is consistent with a demand shock causing the US dollar to depreciate.

The findings are consistent with those of Kilian (2009b) and Peersman and Robays (2009). Kilian (2009b) finds that the global aggregate demand oil price shock, unlike the oil supply shock, has a sustained and significant effect on US output and CPI inflation. Peersman and Robays (2009) find that the global aggregate demand and precautionary demand oil price shocks affect the US dollar-euro exchange rate while the oil supply shock does not. They find that the euro appreciates against the US dollar following a global demand shock, and there is a significant and fairly large short- and long-run euro appreciation after a precautionary demand shock. Peersman and Robays (2009) argue that the appreciation following a rise in the precautionary demand for oil may result from the tendency to invest in commodities as a means to protect against depreciation of the US dollar. A depreciation of the US dollar relative to the euro then happens at the same time as the increased demand for oil, which is what the precautionary demand shock should capture.

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addition, the impact of the global aggregate demand shock is larger than that of the precautionary demand shock. Hence, the results of the impulse response functions show the robustness of the benchmark model. In light of the weak exogenity and Granger causality tests, it is appropriate to carry out a single ECM equation in which the price of oil is an explanatory variable for the exchange rate. The advantage of the ECM is that it allows distinguishing the short and long run effects that portfolio balance models suggest may differ. Also, unlike a VAR model, an ECM does not require causal-ordering assumptions.

When the model is estimated using data for the period 1986:1-2010:4, thus including the recent financial crisis, all the variables are still significant and negative in the short and long run except that the government debt variable has an insignificant short-run effect, as presented in column 2 of Table 2-1.

The first and second stages of the US financial crisis took place in July 2007 and July 2008, respectively, which suggests that the period 2007:3-2010:4 represents an unusual phase. A US financial-crisis dummy variable (DV) that equals zero until 2007:2 and one thereafter is incorporated in the model to examine whether the intercept and/or the coefficients were subject to change due to the US financial crisis in 2007. The benchmark model is re-estimated, adding DV to account for the change in the constant and an interactive DV to account for the change in the impact of the ratio of the US federal debt held by the public to GDP in the short run and long run. In other words, the vector of explanatory variables X_t contains the global-aggregate-demand oil-price-effect, oil-supply-and-precautionary-demand oil-price effect, the ratio of the federal debt held by the public to GDP, and the ratio of the federal debt held by the public to GDP multiplied by the US financial-crisis DV.

In column 3 of Table 2-1, the results are presented. The "Ratio of US Federal Debt held by the Public to GDP" refers to the short-run and long-run effects during the period 1986:1 to 2007:2. The significance of the "Ratio of US Federal Debt held by the Public to GDP multiplied by the US financial-crisis dummy variable (DV)" indicates the importance of accounting for a change in the impact of the government debt variable. The sum of the "Ratio of US Federal Debt held by the Public to GDP" and the "Ratio of US Federal Debt held by the Public to GDP multiplied by the US financial-crisis dummy variable (DV)" shows the short and long-run effects of the ratio of the federal debt held by the public to GDP on the US dollar during the period 2007:3 to 2010:4.[53]

[53] For illustration, if $\mathrm{ER_t} = \alpha_0 + \alpha_0^d \mathrm{d} + \alpha_1 \mathrm{X_t} + \alpha_2(\mathrm{X_t d}) + \varepsilon_t$ where $\mathrm{ER_t}$ is the US exchange rate variable, $\mathrm{X_t}$ is the vector of explanatory variables and d is the US financial-crisis dummy variable that is equal to zero from 1986:1 to 2007:2 and is equal to one from 2007:3 to 2010:4, the impact of $\mathrm{X_t}$ on $\mathrm{ER_t}$ is equal to $\frac{\mathrm{dER_t}}{\mathrm{dX_t}} = \alpha_1$ for the period

Column 3 in Table 2-1 shows that the "Ratio of US Federal Debt held by the Public to GDP multiplied by the interactive Dummy variable (DV)" is significant in the short and long run. The significance and sign of the coefficients on the oil price components and on the government debt variable that captures the movement over the period 1986:1 to 2007:2 are almost identical to those in the 1986:1-2007:2 model.[54] This implies that the dummy variables capture any difference between the two periods.

The government debt variable that captures the movement over the period 1986:1 to 2007:2 is significant and negative in the short and long run. The government debt variable that captures the movement over the period 2007:3 to 2010-4 is negative and significant in the long run, and positive and insignificant in the short run. The positive and insignificant short-run impact of the government debt variable during 2007:3 to 2010:4 suggests that this period is unusual and that the appreciation of the US dollar might be attributed to factors specific to this period, including the global flight to quality into US Treasury bills starting in late 2008 (McCauley and McGuire, 2009).

Overall, the results show that a rise in the price of oil, whether from global-aggregate-demand shocks or other sources, is associated with declines in the US dollar over the period 1986-2010. However, changes in US government debt also account for movements in the exchange rate during this period.

7 Robustness of the Results

First, weak exogeneity and Granger causality tests are applied to check the validity of estimating a single-equation ECM in which the oil price is an explanatory variable for the US dollar. Second, the benchmark ECM is re-estimated with the addition of other variables to check the robustness of the results and the specification of the model. Third, the oil price is used instead of the oil price components to check the

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1986:1-2007:2 and is equal to $\frac{dER_t}{dX_t} = \alpha_1 + \alpha_2$ for the period 2007:3-2010:4. The coefficients α_1 and α_2 are directly estimated.

[54] The components of the oil price changes are statistically different, at a 5% significance level. Results for the F-tests are $F(1, 89) = 4.33$ for the short-run impact and $F(1, 89) = 4.12$ for the long-run impact.

robustness of the results in the benchmark ECM. Finally, the model is estimated using a major currencies index, rather than the broad dollar index.

7.1 Direction of Causality between the US Dollar and the Price of Oil

The causality between oil prices and the exchange rate can go both ways. In this sub-section, the direction of causality between these two variables is studied using the error correction form explained in Appendix 2-3. The goal is to determine whether it is appropriate to estimate an ECM for the US dollar where the oil price is an explanatory variable, and not vice versa. This requires the oil price to be strongly exogenous or at least weakly exogenous. For the oil price to be strongly exogenous, it has to satisfy two conditions: it should be weakly exogenous and it should not be Granger caused by the US dollar exchange rate (Enders, 2004; Charemza and Deadman, 1997).[55] For details, refer to Appendix 2-3. The results are discussed in this sub-section and presented in Table 2-2 where the weak exogeneity and Granger causality tests are carried out for the US dollar exchange rate and the oil price variables using monthly data.

The tests for weak exogeneity – for the periods 1986:01-2007:06 and 1986:01-2010:12 – show that the US dollar significantly responds to the deviation from the long-run equilibrium between the US dollar and the oil price; however the price of oil does not (as shown in Table 2-2, and equations (A1) and (A2)). Hence, the price of oil is weakly exogenous to the US dollar exchange rate, while the US dollar exchange rate is not weakly exogenous to the oil price. Using a Granger causality test in a cointegrated system, the lagged value of the change in the exchange rate in the price-of-oil equation (as shown using equation (A2) and Table 2-2) is insignificant, indicating that the price of oil is not Granger caused by the US dollar.

Given the results for the weak exogeneity and Granger causality tests, the oil price is strongly exogenous. Hence, a single-equation ECM can be employed to explain the exchange rate, taking the oil price as exogenous. In other words, it is reasonable to

[55] These two steps were also implemented by Amano and Van Norden (1998b) and Bénassy-Quéré et al. (2007).

study the relationship between the price of oil and the US dollar in an ECM where causality goes from the price of oil to the US dollar. This is consistent with the Chaudhuri and Daniel (1998), Amano and Van Norden (1998a) and Bénassy-Quéré, et al. (2007) findings regarding the direction of causality between oil prices and the US dollar.[56]

7.2 Checking Robustness of the ECM with the Use of Additional Variables

This sub-section examines the robustness of the estimates in Table 2-1 by considering the importance of other macroeconomic variables that previous studies have found to be determinants of the exchange rate. These variables are the ratio of net foreign assets (NFA) to GDP[57] and the difference between the US Federal Funds Rate (FFR) and the German call money rate. Additional variables that reflect risk in the US asset market and China's role in the world economy are also included. The additional variables that reflect risk in the US asset market are the TED spread (the difference between the three-month London Interbank Offered Rate (LIBOR) and the three-month US Treasury bill rate) and the Volatility Index (VIX). The variable that reflects China's role in the world economy is the ratio of China's imports and exports to the world's imports and exports. Data sources for these additional variables are presented in Appendix 2-1. An overview of these additional variables is provided in Appendix 2-2.

The results in Table 2-3 show that the coefficients on the oil price components and the government debt variable remain quite similar to those in Table 2-1 when additional variables are included. The only exception is when the government debt variable is replaced by the US NFA-to-GDP ratio. In this case, the coefficients on the long-run oil price components increase and the value of the adjustment term drops. This reinforces the view that the government debt variable is important, and that excluding this variable from the estimating equation has important implications for the estimates. The

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[56] Chen et al. (2010, p.1145) find that exchange rate movement can be used to forecast oil price movements in the case of "small commodity exporters". However, in Chapter Two, I focus on the US. I do not study the case of either small economies or oil exporters.

[57] The US NFA-to-GDP ratio may be used to capture the impact of US government debt. However, a better variable than NFA is the US federal debt held by the public. There are two concerns with using the ratio of US NFA to GDP: this variable is hard to calculate and is endogenously determined by foreign and domestic investors' demands for US assets, and the value of NFA endogenously varies with exchange rate movements.

following presents the different cases considered.

The ratio of US NFA to GDP could proxy the increase in demand for US assets and the associated increase in US liabilities. Coudert et al. (2008) find that the US NFA position is a transmission variable between the oil price and the US dollar. Using a multilateral exchange rate, Gourinchas and Rey (2007) show that the increase in the external imbalances variable that incorporates NFA is associated with US currency depreciation.[58] As shown in columns 1 and 2 of Table 2-3, the NFA-to-GDP ratio is significant in the long run, but is insignificant in the short run. In order to avoid potential multicollinearity between the ratio of federal debt held by the public to GDP and the ratio of NFA to GDP, the model is estimated without the former variable.[59] As presented in columns 3 and 4 of Table 2-3, in this case, the ratio of NFA to GDP is insignificant in the short run and significant in the long run in the two time samples.[60]

The interest rate differential between the US Federal Funds Rate (FFR) and the German call money interest rate is added to compare the results to the findings of Amano and Van Norden (1998b). Adding the interest rate differential to the model in Table 2-1, as presented in columns 5 and 6 of Table 2-3, the ratio of the federal debt held by the public to GDP and the oil price components are still significant in the long and short run. As well, the estimated coefficients of these variables do not change much. The interest rate differential, however, is insignificant in the long and short run. The insignificance of the interest rate differential variable is consistent with the findings by Amano and Van Norden (1998b).

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[58] In the Gourinchas and Rey (2007) model, the exchange rate is a function of a derived external imbalances variable, which is the sum of the expected present value of growth of net exports (trade channel) and the expected present value of returns on NFA (valuation channel). An increase in the external imbalances variable implies an increase in the deficit.

[59] The US federal debt held by the public and the US NFA could be multicollinear because both variables capture information on foreign and domestic demands for US assets. As well, the correlation coefficient between the US federal debt held by the public and the US NFA during 1986:1 to 2007:2 is equal to -0.7384.

[60] In the 1986:1-2010:4 model that excludes the ratio of the federal debt held by the public to GDP, a dummy variable and interactive dummy variables were included. The two series used to compute the NFA, following Coudert et al. (2008) - “Foreign-owned assets in the United States, excluding financial derivatives (increase/financial inflow (+))” and “U.S.-owned assets abroad, excluding financial derivatives (increase/financial outflow (-))” - are cumulated to ensure the NFA variable is a stock.

The TED spread reflects the impact of the increase in credit risk and, accordingly, the strain in financial markets[61]. Another measure of risk in the US asset market is the Chicago Board Options Exchange (CBOE) Volatility Index (VIX). When the model in Table 2-1 is augmented with either the TED spread (as presented in columns 7 and 8 of Table 2-3) or the VIX (as presented in columns 9 and 10 of Table 2-3), the oil price components and the ratio of the federal debt held by the public to GDP are still significant in the long run and the short run. Also, the values of the coefficients do not change much. However, the TED spread is significant in the long run, and the VIX is only significant in the short run at a 10% significance level.[62] The sign of the coefficients on these variables are negative. These results suggest that an increase in risk in the US financial market reduces demand for US dollars, causing the dollar to fall in value.[63] Note that the regressions that include the VIX variable are for the periods 1990:1-2007:2 and 1990:1-2010:4 because data on the VIX are available for a shorter sample only.

The ratio of China's imports and exports to the world's imports and exports is used as a measure of China's growing role in the world economy. When adding the China variable to the model in Table 2-1, as presented in columns 11 and 12 of Table 2-3, the oil price and the ratio of the federal debt held by the public to GDP are still significant in the long and short run, and the values of the coefficients do not change much. The China variable is significant in the long run, but its significance in the short run is sensitive to the sample period. The positive sign of the China variable is consistent with the predictions of the portfolio balance analysis literature, to the extent that the increase in China's economic role is associated with an increase in demand for US assets, resulting in upward pressure on the US dollar. As reported by Bénassy-Quéré et al. (2007), China ranks second in the world in terms of foreign exchange reserves, and holds a large stock of US dollar-denominated assets.

[61] Understanding the TED spread, Analysis of current economic conditions and policy. (n.d). Retrieved from http://www.econbrowser.com/archives/2008/09/understanding_t.html

[62] In the short-run, the Ted spread is significant at 10% significance level only, in the two samples.

[63] This result implies that greater risk does not lead to a flight-to-quality to the US dollar. This unexpected result may be due to the low frequency of the data.

7.3 Comparison with Earlier Studies

As mentioned above, Amano and Van Norden (1998a and 1998b), Chaudhuri and Daniel (1998), Chen and Chen (2007), Coudert et al. (2008), and Bénassy-Quéré et al. (2007) find that the relationship between the oil price and the US dollar is significant and positive in the long run, and generally insignificant in the short run. In contrast, the current research finds that the relationship between the supply and demand oil price components and the US dollar is negative in both the short and the long run. The goal of this sub-section is to see if the estimates yield a positive relationship between the oil price and the US dollar, rather than a negative relationship, when the price of oil is used in place of the supply and demand components underlying oil price changes. The results are presented in Table 2-4. The results for the ratio of the federal debt held by the public to GDP are not altered and the real price of oil has a significant and negative impact (implying depreciation) on US dollar movements in the short run and the long run in the two sample periods. So, the results are consistent when I use the oil price or the two components of the oil price.

7.4 Other Variations of the Model

Another variation of the models in Table 2-1 and Table 2-3 involves seasonally adjusting the data for the ratio of the federal debt held by the public to GDP and VIX.[64] The reason for doing this is that the short-run government debt and VIX variables exhibit seasonality. The results in Table 2-5, columns 1 and 2, present this variation of the model in Table 2-1 and show that the government debt variable and oil price components are still significant and negative in the short and long run. The results also show that the change in the value of the coefficients is small. The variation of the specification in Table 2-3 using seasonally adjusted data, not reported here, shows that the government debt and oil price variables are still significant and negative in the short and long run.

[64] A variable is seasonally adjusted by carrying out an OLS regression where the variable is regressed on three seasonal dummy variables and a constant, and retrieving from this regression the sum of the residuals and estimated intercept. When applying Holt-Winters seasonal smoothing and moving average smoothing in STATA to seasonally adjust the variables, the results are unaffected.

Another variation of the model in Table 2-1 involves using the real price-adjusted major dollar index instead of the real price-adjusted broad dollar index. The currencies included in the real price-adjusted major dollar index are the euro, Canadian dollar, Japanese yen, British pound, Swiss franc, Australian dollar and Swedish krona. These currencies, as well as the US dollar, are traded widely in the foreign exchange market and reflect pressures in the international financial market on the US dollar.[65] The results, presented in Table 2-5, columns 3 and 4, show that the government debt variables and oil price components are still significant and negative in the short and long run.

8 Conclusion

In light of the portfolio balance models in Chapter One and Krugman (1980), the negative impact of the long-run effect of the real price of oil found in this chapter is consistent with oil exporters preferring non-US goods. Although they provide data for just one year, Ruiz and Vilarubia (2007) find that OPEC and Russian imports in 2004 were mostly from Asia and Europe. As for the short-run impact of the price of oil, the negative sign of the oil price variable is more likely if oil exporters have a higher preference for non-US assets, as put forward by Krugman (1980). Moreover, the short-run condition in Chapter One, which builds on Krugman (1980) and allows for a more general asset market, shows that US dollar appreciation is less likely relative to the condition posited by Krugman (1980). Ruiz and Vilarubia (2007) point out that the United Kingdom is still a considerably important financial center for oil exporters. On the other hand, the Federal Reserve Monetary Policy Reports to the Congress for February 2009, July 2008, July 2007 and February 2007 state that, after the financial chaos in 2007, both official and private foreign investors were more inclined to invest in US Treasuries due to a flight to

[65] The inflation rates in the countries whose currencies are used to compute the US real price-adjusted major dollar index "are similar to" the inflation rate in the US (Federal Reserve, 2005, p.7). Therefore, both the real and nominal major dollar indices are informative of the long-run trend of US goods competitiveness relative to the other countries in the index (Federal Reserve, 2005).

safety.[66] However, official foreign inflows were the main source of financial flows and were principally directed from Asian Central Banks rather than from oil exporters.[67]

The current research separates the oil price effect into two components. The first component is referred to as the global-aggregate-demand oil-price effect and captures the increase in oil prices due to the increase in global economic activity. The second component is referred to as the oil-supply-and-precautionary-demand oil-price effect and reflects changes in oil prices driven by precautionary demand and oil supply changes. An error correction model (ECM) that incorporates the two components of oil price changes and the government debt variable is estimated. According to the Pesaran et al. (2001) bounds test, there is a long-run relationship between the US dollar, the two components of oil price movements, and the ratio of the federal debt held by the public to GDP. The estimates show that the global-aggregate-demand oil-price effect, oil-supply-and-precautionary-demand oil-price effect, and the ratio of the US federal debt held by the public to GDP are significant short- and long-run determinants of US dollar movements.

The estimates show that a rise in the two oil price effects causes the US dollar to depreciate in the short and long run. Also, the global-aggregate-demand oil-price effect has a larger impact than the oil-supply-and-precautionary-demand oil-price effect, possibly because the former may be capturing the direct impact of the rise in oil prices on the US dollar as well as the increase in the global demand for assets that may accompany global growth. Further to this point, as explained by Campbell et al. (2010), during periods of economic downturn, investors' demand for US assets increases due to the flight-to-quality effect. This implies that during booms a negative impact of the global-aggregate-demand oil-price effect on the US dollar is expected. The negative impact of

[66] Before the global financial chaos, in late 2007, the main source of financial inflows was foreign private demand for corporate bonds, Government-Sponsored Enterprise (GSE) bonds and corporate equities, rather than U.S. Treasuries (Board of Governors of Federal Reserve, February 2009, July 2008, July 2007 and February 2007).

[67] As a proxy, OPEC holdings of US treasury securities as a share of the total foreign holdings of US treasury securities was around 5-6% during the early 2000s, except in 2003 and 2004 when it tended to be lower, whereas China's share increased from 6% in early 2000 to around 26 % in late 2010 (Source: Treasury International Capital System (TIC), US Department of Treasury).

the oil-supply-and-precautionary-demand oil-price effect can be attributed to the increase in the demand for oil as an asset to hedge against the US dollar depreciation.

The negative impact of the two oil price effects is not consistent with the findings of Amano and Van Norden (1998a and 1998b), Chaudhuri and Daniel (1998), Chen and Chen (2007), Coudert et al. (2008), and Bénassy-Quéré et al. (2007) who do not account for the source of oil price changes. In order to check the robustness of this finding, an ECM is estimated using the oil price in place of the two components underlying oil price changes. The price of oil and the federal-debt-held-by-the-public-to-GDP ratio are found to be significant short- and long-run determinants of US dollar movements. The estimates show that an increase in oil prices causes the US dollar to depreciate in the short and long run.[68] This result is not in accord with the previous empirical research. However, it is consistent with the portfolio balance analysis literature.

The results show that an increase in the ratio of federal debt held by the public to GDP leads to a US dollar depreciation in the short and long run. This is compatible with the previous empirical literature (McMillin and Koray, 1990; Cayen et al., 2010; Kim and Roubini, 2008; Koray and McMillan, 2007; and Muller, 2004) and theoretical portfolio balance analyses. The results also show that further analysis of the period 2007:3-2010:4 is needed to comprehend the period-specific factors behind the US dollar and government debt movements.

The results are robust to variations of the model. First, the direction of the relationship between the price of oil and the US dollar is examined. The oil price is weakly exogenous and is not Granger caused by the US dollar. This is consistent with a model specification in which the oil price is an explanatory variable in a US dollar regression. Second, additional variables, including interest rate differentials, the US NFA-to-GDP ratio, the TED spread, the VIX, and the ratio of China's total imports and exports to the world's total imports and exports, are added to the benchmark model. The

[68] The negative impact of an oil-price increase on the US dollar would be expected if oil is used more intensively in the US relative to the rest of the world.

estimated coefficients on the oil price components and the ratio of the federal debt held by the public to GDP stay approximately the same in terms of value and significance. In the case when the US NFA-to-GDP ratio is included and the ratio of the federal debt held by the public to GDP is excluded, the adjustment term drops and the value of the long run coefficients on the oil price components increase; however, the NFA-to-GDP ratio does not add explanatory power to the model. These findings emphasize the importance of the government debt variable. In addition, the results are robust when accounting for seasonality and when using an alternate measure of the US dollar.

In summary, the current research is a contribution to the existing literature on the US dollar and oil prices and on the US dollar and government debt in that it provides an empirical model of exchange rate determination that incorporates both the oil price and the ratio of the US federal debt held by the public to GDP. Moreover, the empirical analysis in this chapter accounts for the source of oil price changes. This is important because the composition of the demand and supply shocks underlying movements in oil prices changes over time, which may result in a variation in the response of the US dollar. Estimating an ECM is also beneficial since it allows the short- and long-run effects to be identified; which are important aspects of the portfolio balance model developed in Chapter One. Furthermore, the empirical results for the impact of changes in oil prices and the supply of US assets generally support the predictions of the portfolio balance model in Chapter One.

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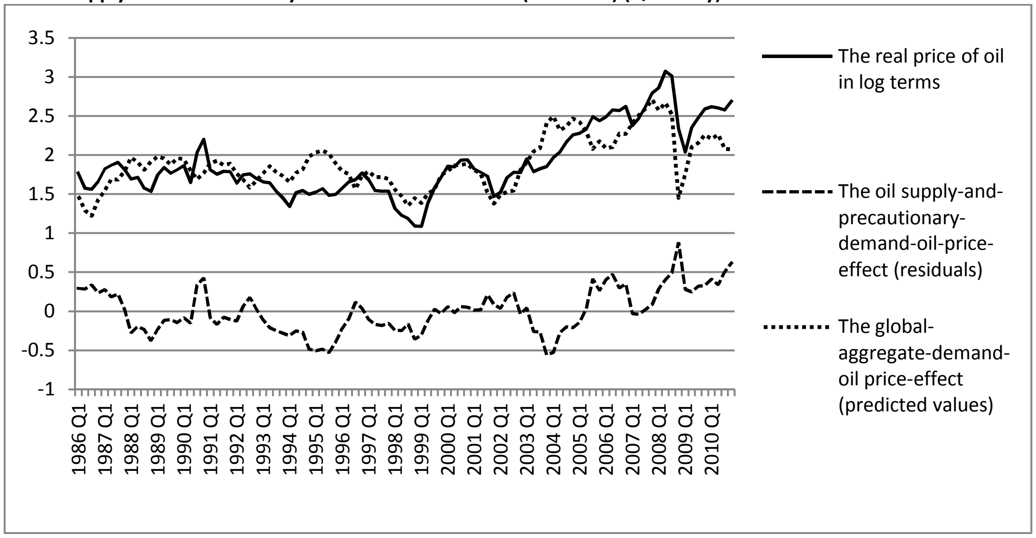
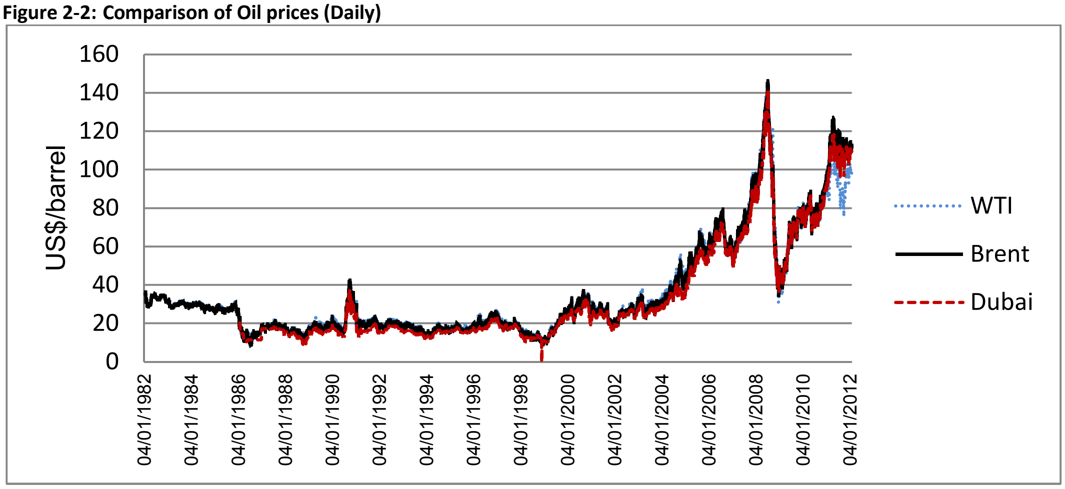
Figures

Figure 2-1: The Log of the Real WTI Oil Price, the Global-Aggregate-Demand-Oil Price Effect (Predicted Values), and the Oil-Supply-and-Precautionary-Demand-Oil-Price Effect (Residuals) (Quarterly)



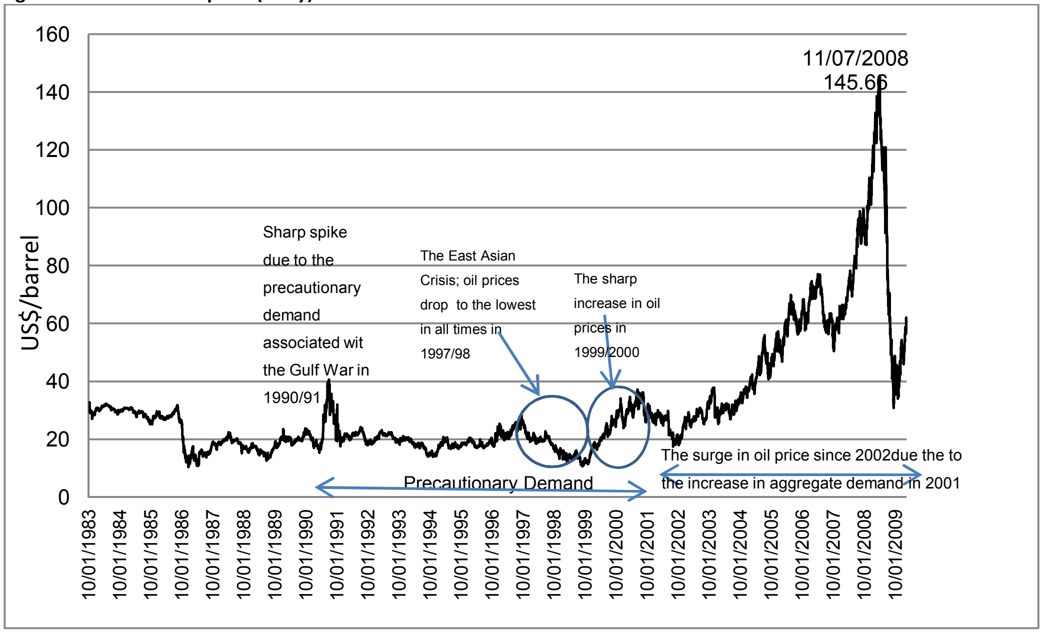
Source: Author's calculations using data from the International Financial Statistics for the real price of oil (WTI oil price and US CPI) and from URL: http://www-personal.umich.edu/~lkilian/reaupdate.tx for the values of the Kilian index.

Figure 2-2: Comparison of Oil prices (Daily)



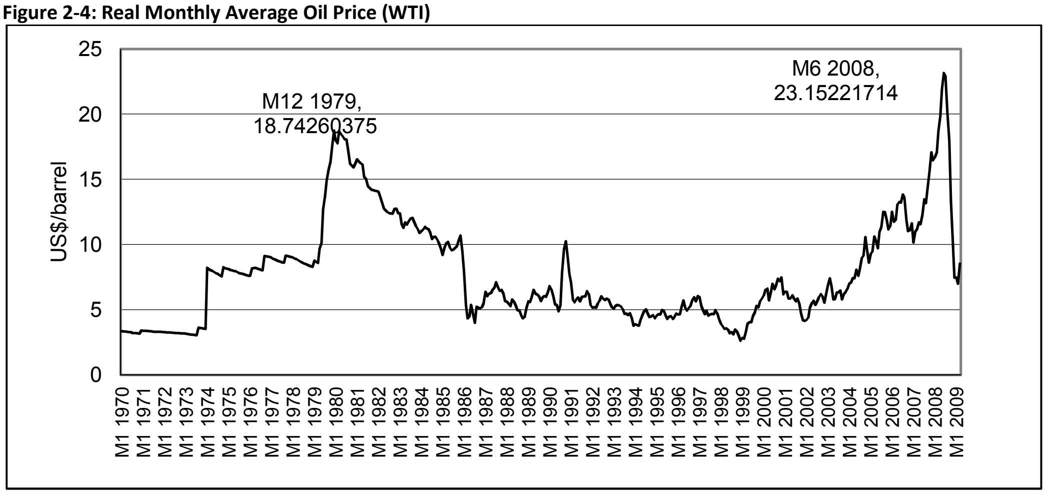
Source: DataStream.

Figure 2-3: The WTI Oil price (Daily)



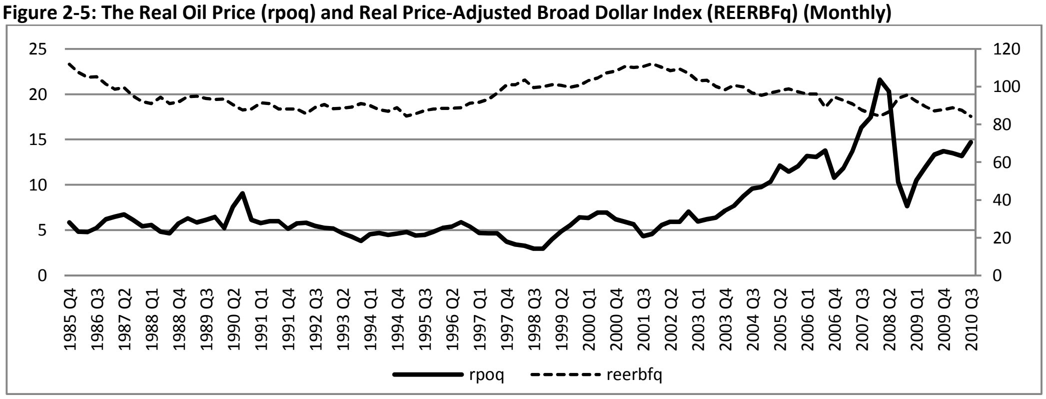
Source: DataStream.

Figure 2-4: Real Monthly Average Oil Price (WTI)



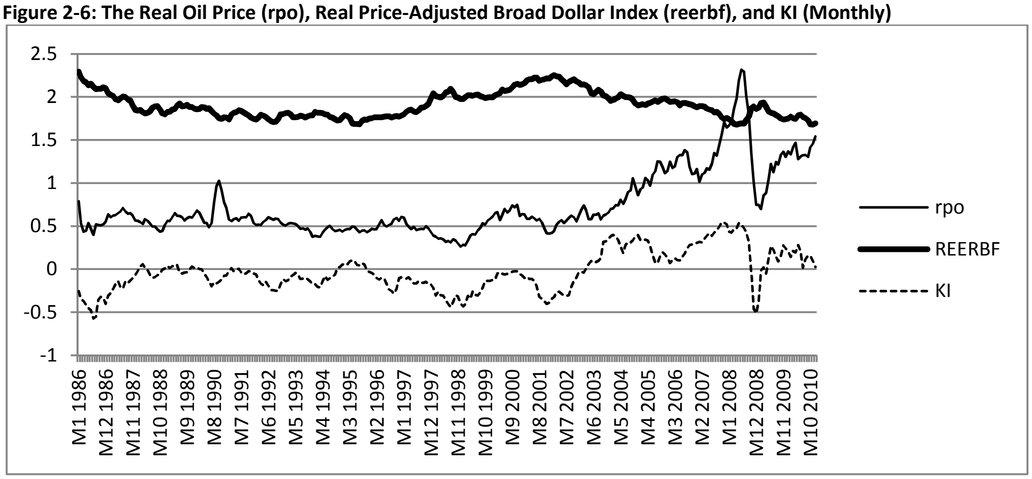
Source: The source for the WTI price and the consumer price index (CPI) is the International Financial Statistics (IFS).

Figure 2-5: The Real Oil Price (rpoq) and Real Price-Adjusted Broad Dollar Index (REERBFq) (Monthly)



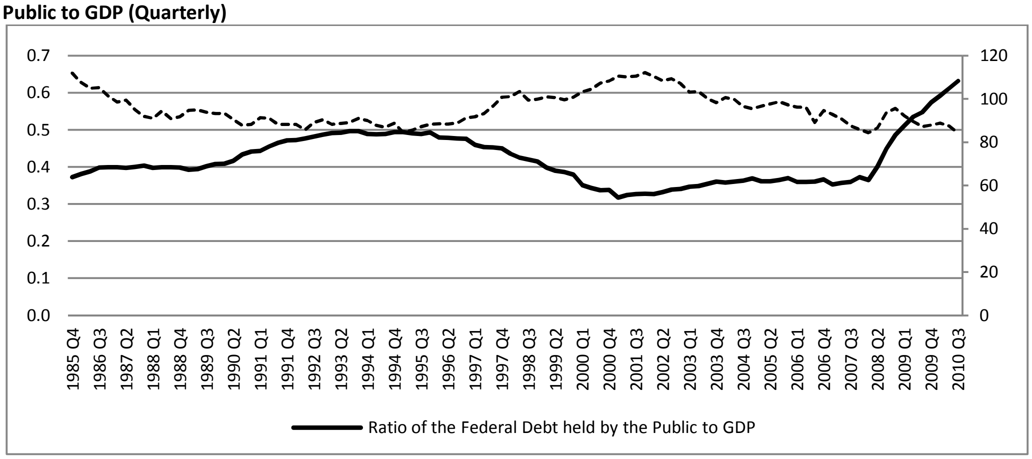
Source: The source for rpoq (on the primary axis) is the IFS and the source for REERBFq (on the secondary axis) is the US Federal Reserve.

Figure 2-6: The Real Oil Price (rpo), Real Price-Adjusted Broad Dollar Index (reerbf), and KI (Monthly)



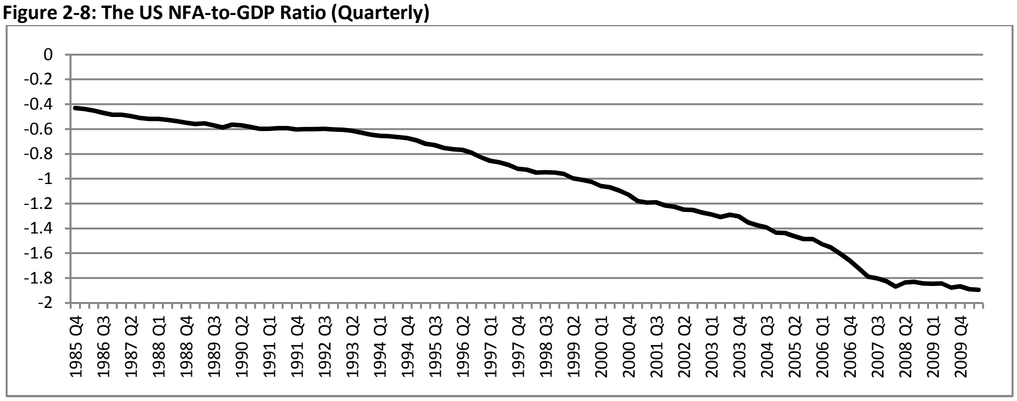
Source: The source for rpo is the IFS, the source for REERBF is the US Federal Reserve, and the source for KI is Kilian (2009b) and URL: http://www-personal.umich.edu/~lkilian/reaupdate.txt[69]

Figure 2-7: The Real Price-Adjusted Broad Dollar Index (REERBFq) and the Ratio of the Federal Debt held by the Public to GDP (Quarterly)



Source: The broad dollar index is on the secondary axis, and the ratio of the US federal debt held by the public to GDP is on the primary axis. The source of the broad dollar index is the US Federal Reserve, the source of the US GDP is the Bureau of Economic Analysis (BEA), and the source the US federal debt held by the public is the Federal Reserve Bank of St. Louis (FRED).

Figure 2-8: The US NFA-to-GDP Ratio (Quarterly)



Source: Bureau of Economic Analysis.

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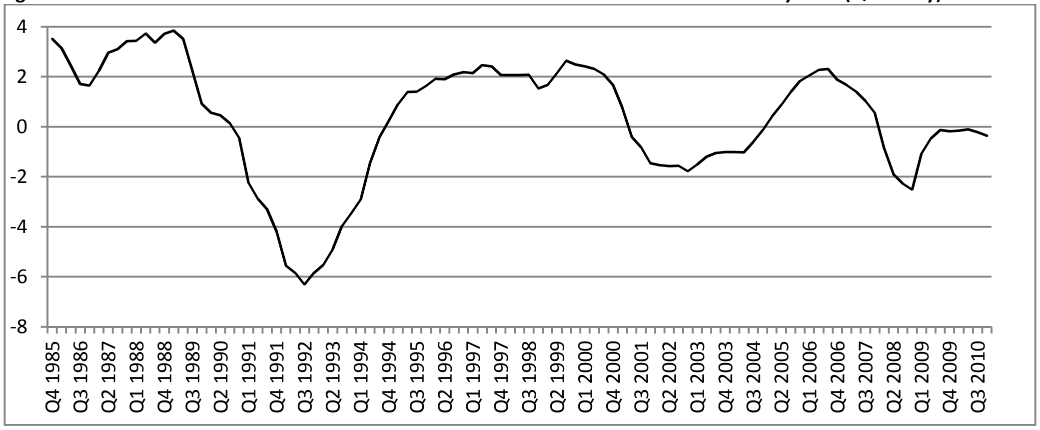
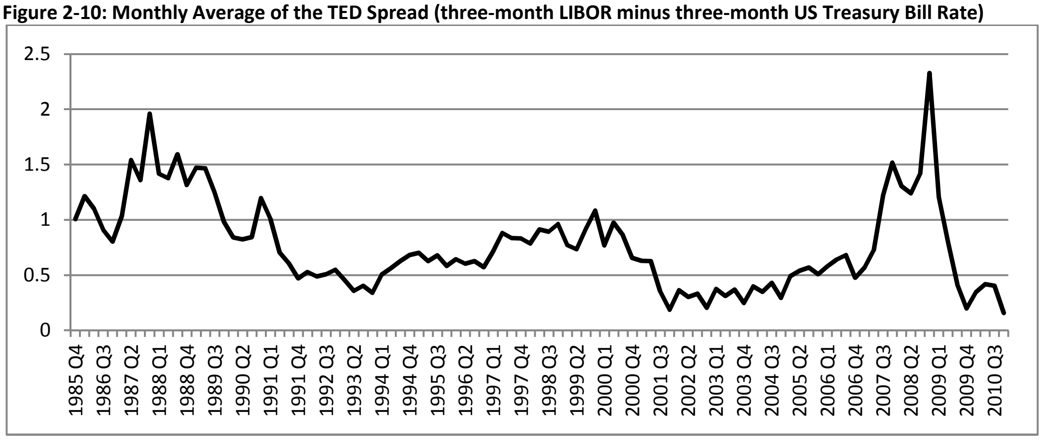
[69] The real price of oil and real price-adjusted broad dollar Index are rescaled in order to fit the three variables into one graph for illustration. For the values of the real price of oil and real price-adjusted broad dollar Index, refer to Figure 2-5.

Figure 2-9: The Interest Rate Differential between the US FFR and the German Call Money Rate (Quarterly)



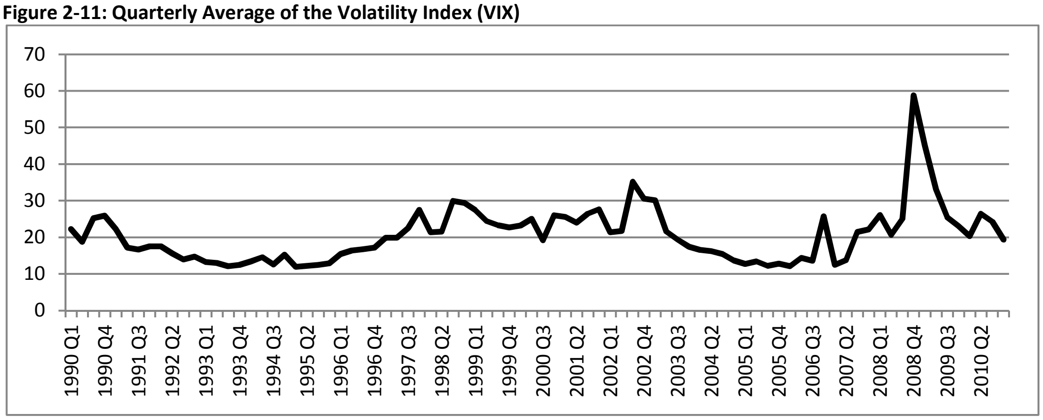
Source: International Financial Statistics.

Figure 2-10: Monthly Average of the TED Spread (three-month LIBOR minus three-month US Treasury Bill Rate)



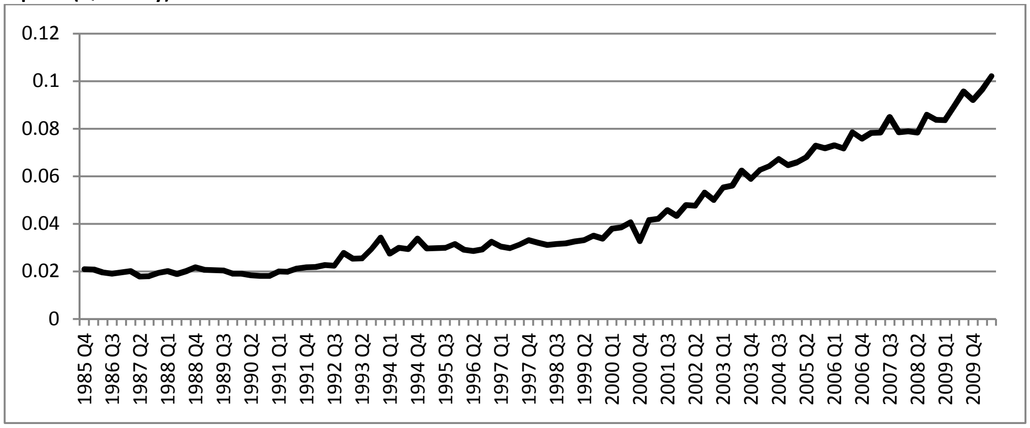
Source: International Financial Statistics.

Figure 2-11: Quarterly Average of the Volatility Index (VIX)



Source: Chicago Board Options Exchange (CBOE).

Figure 2-12: The Seasonally-Adjusted Ratio of China Mainland Imports and Exports to the World's Import and Exports (Quarterly)



Source: Bureau of Economic Analysis and International Financial Statistics and author's calculations.

Tables of Results

Table 2-1: ECM output: The dependent variable is the log of the real price-adjusted broad dollar index, and the explanatory variables are the ratio of the federal debt held by the public to GDP, the global-aggregate-demand oil-price effect, and the oil-supply-and-precautionary-demand oil-price effect.

Short Run	1986:1-2007:2 [†]	1986:1-2010:4 [†]	1986:1-2010:4 [†]
Global-Aggregate-Demand Oil-Price Effect	-0.097412*** ***-3.36***	-0.0832398*** ***-4.83***	-0.0859208*** ***-4.63***
Oil-Supply-and-Precautionary-Demand Oil-Price Effect	-0.0500326*** ***-2.68***	-0.0400696** ***-2.32***	-0.0536417*** ***-3.15***
Ratio of US Federal Debt held by the Public to GDP	-1.088749*** ***-3.45***	-0.2605145 *-1.01*	-1.104937*** ***-3.67***
Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)			1.626564*** ***3.07***
Sum of the coefficients on the variables "Ratio of US Federal Debt held by the Public to GDP" plus "Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)"			0.5216265 *1.15*
Adjustment term	-0.3718585[+++] ***-4.92***	-0.1867623[+] ***-3.66***	-0.3772218[+++] ***-5.40***
Long Run			
Global-Aggregate-Demand Oil-Price Effect	-0.1462591*** ***-5.21***	-0.1140634*** ***-2.85***	-0.1298827*** ***-6.02***
Oil-Supply-and-Precautionary-Demand Oil-Price Effect	-0.0700016** ***-2.22***	-0.0206133 *-0.38*	-0.0703409** ***-2.44***
Ratio of US Federal Debt held by the Public to GDP	-1.294791*** ***-9.86***	-0.7756584*** ***-3.95***	-1.295219*** ***-10.49***
Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)			0.9841998*** ***4.79***
Sum of the coefficients on the variables "Ratio of US Federal Debt held by the Public to GDP" plus "Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)"			-0.311019* ***-1.94***
Constant	1.990013*** ***4.85***	0.9497384*** ***3.61***	2.009144*** ***5.33***
Dummy Variable (equals one from 2007:3 to 2010:4)			-0.1575399*** ***-3.42***
R^2	0.3443	0.2991	0.4612
Ramsey RESET test adding the quadratic value of predicted value of the exchange rate variable	t=-0.75[(a)]	t=1.48[(a)]	t=-0.52[(a)]
Ramsey RESET test adding the predicted value of the exchange rate variable raised to the powers two, three, and four (F-test)	F(3, 75) =0.85[(a)]	F(3, 89) =0.95[(a)]	F(3, 86) =0.50[(a)]
Breusch-Godfrey LM test for autocorrelation (AR(1) (Chi-square test)	chi2=0.021[(b)]	chi2=0.935[(b)]	chi2=0.000[(b)]

Data are quarterly. The values of the estimates are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.

The t-statistics for the long-run effects of the variables are computed following the delta method.

(*), (**) and (***) indicate the 10%, 5% and 1% significance levels for the short- and long-run effects of the variables.

($^+$), ($^{++}$) and ($^{+++}$) indicate the 10%, 5% and 1% significance levels for the conclusively non-zero adjustment term using the critical values for the bounds test from table CII in Pesaran et al. (2001). Table CII provides the critical values for the case when there is an intercept, but no trend.

(†) For the coefficient on each explanatory variable in the first two columns and the un-shaded cells of column 3, using $\Delta ER_t = \alpha ER_{t-1} + \theta_1 \Delta X_t + \theta_2 X_{t-1} + \theta_0 + \varepsilon_t$ where ΔER_t is the change in the log of the exchange rate and X_t is vector of explanatory variables, the short-run impact of X_t on ER_t is equal to $\frac{d\Delta ER_t}{d\Delta X_t} = \theta_1$ and the long-run impact is equal to $\frac{dER_{t-1}}{dX_{t-1}} = -\frac{\theta_2}{\alpha}$.

(a) Cannot reject the null hypothesis of model has no omitted variables at 5% significance level.

(b) Cannot reject the null hypothesis of no serial correlation at 5% significance level.

Table 2-2: Weak Exogeneity and Granger Causality; the real price-adjusted broad dollar and real oil price variables are in log terms

Following the SIC, one lag for the left-had-side variables is the appropriate number of lags to be considered as reported for the following two equations:

$$\Delta ER_t = a_{10} + \alpha_{ER} ER_{t-1} + \delta_{ER} PO_{t-1} + a_{11}(1)\Delta ER_{t-1} + a_{12}(1)\Delta PO_{t-1} + \varepsilon_{ER_t} \quad \text{A1}$$

$$\Delta ER_t = a_{10} + \alpha_{ER}\left(ER_{t-1} - \frac{\delta_{ER}}{-\alpha_{ER}} PO_{t-1}\right) + a_{11}(1)\Delta ER_{t-1} + a_{12}(1)\Delta PO_{t-1} + \varepsilon_{ER_t}$$

(Transformed Version) A 1 '

$$\Delta PO_t = a_{20} + \alpha_{PO} ER_{t-1} + \delta_{PO} PO_{t-1} + a_{21}(1)\Delta ER_{t-1} + a_{22}(1)\Delta PO_{t-1} + \varepsilon_{PO_t} \quad \text{A2}$$

$$\Delta PO_t = a_{20} + \alpha_{PO}\left(ER_{t-1} - \frac{\delta_{PO}}{-\alpha_{PO}} PO_{t-1}\right) + a_{21}(1)\Delta ER_{t-1} + a_{22}(1)\Delta PO_{t-1} + \varepsilon_{PO_t}$$

(Transformed Version) A 2 '

Parameter	1986:01-2007:06	1986:01-2010:12
α_{ER}	-0.0222308** ***-2.49***	-0.0239348*** ***-2.70***
α_{PO}	0.0002991 *0.00*	-0.0370293 *-0.58*
$a_{21}(1)$	-0.1852146 *-0.43*	-0.6079038 *-1.56*

Monthly data are used.
The values of the estimates are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.
(*), (**) and (***) indicate the 10%, 5% and 1% significance levels.

Comment:
To carry out inference in a single equation for the exchange rate, the oil price has to be strongly exogenous or at least weakly exogenous. For the price of oil to be strongly exogenous, it has to be weakly exogenous and to not be Granger caused by the exchange rate (Enders, 2004; and Charemza and Deadman, 1997).

First, testing for weak exogeneity involves testing for the significance of the adjustment terms in the autoregressive equations for the US dollar (equation (A1)) and the price of oil (equation (A2)). When $\alpha_{PO} = 0$ and $\alpha_{ER} \neq 0$, the price of oil does not respond to deviations from the long-run equilibrium relationship while the US dollar does respond; accordingly, the price of oil is said to be weakly exogenous. In that case, the US dollar does all the adjustment (Enders, 2004).

Second, testing for the Granger causality, for the cointegrated system presented by equations (A1) and (A2), is carried out by testing for the significance of $a_{21}(1)$ in equation (A2). When $a_{21}(1) = 0$, oil price movements are not explained by exchange rate movements; i.e., exchange rate changes do not Granger cause oil price changes.

Since α_{PO} and $a_{21}(1)$ are not statistically different from zero at any significance level, the price of oil is weakly exogenous and is not Granger caused by the exchange rate; i.e., it is strongly exogenous. In this case, it is appropriate to carry out inference based on a single equation for the exchange rate.

For the purpose of testing for strong exogeneity, the linear version of the exchange rate and oil price equations (equations (A1) and (A2)) are the ones individually estimated. For details, refer to Appendix 2-3.

Table 2-3: ECM output: The dependent variable is the log of the real price-adjusted broad dollar index, and the explanatory variables are the two oil price components and the ratio of the US federal debt held by the public to GDP along with the additional variables.

	1986:1-2007:2	1986:1-2010:4	1986:1-2007:2	1986:1-2010:4	1986:1-2007:2	1986:1-2010:4
Short Run	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Global-Aggregate-Demand Oil-Price Effect	-0.1163489*** ***-4.00***	-0.1017781*** ***-5.34***	-0.0871765*** ***-2.85***	-0.0949903*** ***-5.43***	-0.114914*** ***-3.56***	-0.0988486*** ***-4.74***
Oil-Supply-and-Precautionary-Demand Oil-Price Effect	-0.0573399*** ***-3.14***	-0.0573152*** ***-3.44***	-0.0365729* ***-1.88***	-0.0497797*** ***-2.82***	-0.0581423*** ***-2.95***	-0.0594104*** ***-3.42***
Ratio of US Federal Debt held by the Public to GDP	-0.7711318** ***-2.36***	-0.8004481** ***-2.56***			-1.249688*** ***-3.65***	-1.248725*** ***-3.84***
Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)		0.9958645* ***1.76***				1.383989** ***2.33***
Sum of the coefficients on the variables "Ratio of US Federal Debt held by the Public to GDP" plus "Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)"		0.1954164 *0.42*				0.1352638 *0.26*
Ratio of US NFA to GDP	0.0412644 *0.25*	0.0690352 *0.51*	0.0621857 *0.34*	-0.0632012 *-0.45*		
Interest Rate Differential between the US and Germany					0.004547 *0.91*	0.00465 *1.06*
Adjustment term	-0.4160246+++ ***-5.58***	-0.4152437+++ ***-6.01***	-0.1564872+ ***-3.76***	-0.1190909+ ***-3.54***	-0.4159231+++ ***-5.09***	-0.4136649+++ ***-5.63***
Long Run						
Global-Aggregate-Demand Oil-Price Effect	-0.1936004*** ***-6.57***	-0.1625498*** ***-7.11***	-0.2759358*** ***-3.25***	-0.2972301*** ***-3.36***	-0.1531683*** ***-6.06***	-0.1323137*** ***-6.77***
Oil-Supply-and-Precautionary-Demand Oil-Price Effect	-0.0749578*** ***-2.69***	-0.0723943*** ***-2.82***	-0.1061252 *-1.26*	-0.1960339* ***-1.92***	-0.0622474** ***-2.22***	-0.0640303** ***-2.45***
Ratio of US Federal Debt held by the Public to GDP	-1.09639*** ***-7.92***	-1.095499*** ***-8.26***			-1.374844*** ***-11.12***	-1.373386*** ***-11.73***
Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)		0.8711443*** ***3.78***				1.065886*** ***5.68***
Sum of the coefficients on the variables "Ratio of US Federal Debt held by the Public to GDP" plus "Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)"		-0.2243551 *-1.25*				-0.3074996** ***-2.12***
Ratio of US NFA to GDP	-0.0678335*** ***-2.64***	-0.0663391*** ***-2.76***	-0.242873*** ***-3.85***	-0.2065425*** ***-2.79***		
Interest Rate Differential between the US and Germany					-0.0033078 *-1.39*	-0.0032435 *-1.43*
Constant	2.203278*** ***5.47***	2.179316*** ***5.87***	0.7562214*** ***3.76***	0.5813802*** ***3.60***	2.245576*** ***5.02***	2.219448*** ***5.57***
Dummy Variable (equals one from 2007:3 to 2010:4)		-0.166009*** ***-3.44***				-0.1790334*** ***-3.80***
R^2	0.4057	0.5083	0.2469	0.3185	0.3690	0.4823
Ramsey RESET test adding the quadratic value of predicted value of the exchange rate variable	F(1, 75) = 0.87[a]	F(1, 84) = 0.03[a]	F(1, 77) = 0.07[a]	F(1, 89) = 0.02[a]	F(1, 75) = 0.50[a]	F(1, 86) = 0.50[a]
Ramsey RESET test adding the predicted value of the exchange rate variable raised to the powers two, three, and four (F-test)	F(3, 73) = 0.46[a]	F(3, 82) = 0.44[a]	F(3, 75) = 0.62[a]	F(3, 87) = 0.02[a]	F(3, 73) = 0.89[a]	F(3, 84) = 0.64[a]
Breusch-Godfrey LM test for autocorrelation (AR(1) (Chi-square test)	chi2= 0.192[b]	chi2= 0.217[b]	chi2= 0.230[b]	chi2= 0.002[b]	chi2= 0.016[b]	chi2= 0.003[b]

Data are quarterly. The values of the estimates are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics. The t-statistics for the long-run effects of the variables are computed following the delta method. (*), (**) and (***) indicate the 10%, 5% and 1% significance levels for the short- and long-run effects of the variables. (+), (++) and (+++) indicate the 10%, 5% and 1% significance levels for the conclusively non-zero adjustment term using the critical values for the bounds test from table CII in Pesaran et al. (2001). Table CII provides the critical values for the case when there is an intercept, but no trend. (1) Indicates inconclusive results at 10% significance level, and non-rejection of the null hypothesis of no cointegration at 5% and 1% significance levels. (a) Cannot reject the null hypothesis of model has no omitted variables at 5% significance level. (b) Cannot reject the null hypothesis of no serial correlation at 5% significance level.

Table2-3 (Continued): ECM output: The dependent variable is the log of the real price-adjusted broad dollar index, and the explanatory variables are the two oil price components and the ratio of the US federal debt held by the public to GDP along with the additional variables.

	1986:1-2007:2	1986:1-2010:4	1990:1-2007:2	1990:1-2010:4	1986:1-2007:2	1986:1-2010:4
Short Run	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Global-Aggregate-Demand Oil-Price Effect	-0.1018046*** -3.54	-0.1008618*** -5.55	-0.1170185*** -3.71	-0.1126195 -5.57***	-0.1218328 -4.08***	-0.1076933 -5.64***
Oil-Supply-and-Precautionary-Demand Oil-Price Effect	-0.057654*** -3.15	-0.0641676*** -3.86	-0.0629153*** -2.80	-0.0757246 -3.97***	-0.0596804 -3.24***	-0.0583254 -3.54***
Ratio of US Federal Debt held by the Public to GDP	-1.294758*** -4.21	-1.27267*** -4.38	-1.181147*** -3.70	-1.190588 -3.90***	-0.9172182 -2.91***	-0.9706264 -3.22***
Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)		1.837789*** 3.63		1.678996 3.16***		1.034494 1.90*
Sum of the coefficients on the variables “Ratio of US Federal Debt held by the Public to GDP“ plus “Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)”		0.5651186 1.31		0.4884087 1.11		0.0638675 0.14
TED Spread	-0.022086* -1.97	-0.0155068* -1.92				
Log of the VIX			-0.0342745** -2.22	-0.0242597 -1.79*		
Ratio of China’s Imports and Exports to the World’s Total Imports and Exports					0.8206024 1.03	1.398789 2.20**
Adjustment term	-0.4494205^{+++} -5.80	-0.4635199^{+++} -6.49	-0.4443361$^{(2)}$ -3.56	-0.4830781^{++} -4.22	-0.4320991^{+++} -5.55	-0.4352275^{+++} -6.19
Long Run						
Global-Aggregate-Demand Oil-Price Effect	-0.1639826*** -7.33	-0.1422428*** -8.33	-0.1730134*** -4.39	-0.1558161*** -5.67	-0.2033289*** -6.50	-0.1738079*** -7.35
Oil-Supply-and-Precautionary-Demand Oil-Price Effect	-0.0553298** -2.23	-0.0584397*** -2.62	-0.0826576*** -2.94	-0.090688*** -3.86	-0.0804285*** -2.99	-0.0769582*** -3.16
Ratio of US Federal Debt held by the Public to GDP	-1.281605*** -12.25	-1.296534*** -13.55	-1.436287*** -9.00	-1.479518*** -11.10	-1.161485*** -9.52	-1.157751*** -10.11
Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)		0.7451789*** 4.15		1.135571*** 6.47		0.7347112*** 3.67
Sum of the coefficients on the variables “Ratio of US Federal Debt held by the Public to GDP“ plus “Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)”		-0.5513552*** -3.78		-0.3439467** -2.53		-0.4230402*** -2.95
TED Spread	-0.0474189*** -3.31	-0.0471661*** -3.64				
Log of the VIX			-0.0250529 -0.74	-0.0321383 -1.14		
Ratio of China’s Imports and Exports to the World’s Total Imports and Exports					1.188764** 2.58	1.107161** 2.61
Constant	2.430263*** 5.74	2.493859*** 6.43	2.460387*** 3.53	2.680744*** 4.21	2.313875*** 5.48	2.310129*** 6.11
Dummy Variable (equals one from 2007:3 to 2010:4)		-0.1345136*** -3.02		-0.2135875*** -3.16		-0.1400944*** -3.16
R^2	0.4276	0.5272	0.4275	0.5439	0.4013	0.5198
Ramsey RESET test adding the quadratic value of predicted value of the exchange rate variable	F(1, 74) = 0.15$^{(a)}$	F(1, 86) = 0.16$^{(a)}$	F(1, 58) = 2.59$^{(a)}$	F(1, 69) = 0.26$^{(a)}$	F(1, 75) = 0.31$^{(a)}$	F(1, 86) = 0.03$^{(a)}$
Ramsey RESET test adding the predicted value of the exchange rate variable raised to the powers two, three, and four (F-test)	F(3, 73) = 0.25$^{(a)}$	F(3, 84) = 0.22$^{(a)}$	F(3, 56) = 2.55$^{(a)}$	F(3, 67) = 1.06$^{(a)}$	F(3, 73) = 0.47$^{(a)}$	F(3, 84) = 0.13$^{(a)}$
Breusch-Godfrey LM test for autocorrelation (AR(1) (Chi-square test)	chi2= 0.338$^{(b)}$	chi2= 0.296$^{(b)}$	chi2= 0.284$^{(b)}$	chi2= 0.102$^{(b)}$	chi2= 0.010$^{(b)}$	chi2= 0.003$^{(b)}$

Data are quarterly. The values of the estimates are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics. The t-statistics for the long-run effects of the variables are computed following the delta method. (*), (**) and (***) indicate the 10%, 5% and 1% significance levels for the short- and long-run effects of the variables. (+), (++) and (+++) indicate the 10%, 5% and 1% significance levels for the conclusively non-zero adjustment term using the critical values for the bounds test from table CII in Pesaran et al. (2001). Table CII provides the critical values for the case when there is an intercept, but no trend. (a) Cannot reject the null hypothesis of model has no omitted variables at 5% significance level. (b) Cannot reject the null hypothesis of no serial correlation at 5% significance level.

Table 2-4 ECM output: The dependent variable is the log of the real price-adjusted broad dollar index, and the explanatory variables are the ratio of the federal debt held by the public to GDP and the log of the real price of oil.

Short Run	1986:1-2007:2†	1986:1-2010:4†	1986:1-2010:4††
Log of the Real Price of Oil	-0.0596593*** ***-3.25***	-0.0632075*** ***-4.18***	-0.0679651*** ***-4.21***
Ratio of US Federal Debt held by the Public to GDP	-1.04365*** ***-3.32***	-0.1494493 *-0.58*	-1.078634*** ***-3.58***
Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)			1.97127*** ***3.82***
Sum of the coefficients on the variables “Ratio of US Federal Debt held by the Public to GDP“ plus “Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)”			0.8926369** ***2.05***
Adjustment term	-0.3052708+++ ***-4.71***	-0.1666265++ ***-3.83***	-0.3220035+++ ***-5.27***
Long Run			
Log of the Real Price of Oil	-0.1142501*** ***-4.22***	-0.0774678** ***-2.00***	-0.1090011*** ***-4.62***
Ratio of US Federal Debt held by the Public to GDP	-1.317802*** ***-8.28***	-0.7742681*** ***-3.43***	-1.316539*** ***-9.12***
Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)			0.9906662*** ***4.11***
Sum of the coefficients on the variables “Ratio of US Federal Debt held by the Public to GDP“ plus “Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)”			-0.3258725* ***-1.71***
Constant	1.618534*** ***4.64***	0.8350721*** ***3.78***	1.70424*** ***5.17***
Dummy Variable (equals one from 2007:3 to 2010:4)			-0.141403*** ***-3.07***
R^2	0.3060	0.2461	0.4277
Ramsey RESET test adding the quadratic value of predicted value of the exchange rate variable	t= -0.56[a]	t= 2.04	t= 0.36[a]
Ramsey RESET test adding the predicted value of the exchange rate variable raised to the powers two, three, and four (F-test)	F(3, 77) = 0.65[a]	F(3, 91) = 2.15	F(3, 88) = 0.75[a]
Breusch-Godfrey LM test for autocorrelation (AR(1) (Chi-square test)	chi2 =0.066[b]	chi2 = 1.917[b]	chi2 = 0.002[b]

Data are quarterly.
The values of the estimates are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.
The t-statistics for the long-run effects of the variables are computed following the delta method.
(*), (**) and (***) indicate the 10%, 5% and 1% significance levels for the short- and long-run effects of the variables.
(+), (++) and (+++) indicate the 10%, 5% and 1% significance levels for the conclusively non-zero adjustment term using the critical values for the bounds test from table CII in Pesaran et al. (2001). Table CII provides the critical values for the case when there is an intercept, but no trend.
[a] Cannot reject the null hypothesis of model has no omitted variables at 5% significance level.
[b] Cannot reject the null hypothesis of no serial correlation at 5% significance level.

Table 2-5: ECM output: In columns (1) and (2), the dependent variable is the log of the real price-adjusted broad dollar index, and the explanatory variables are the global-aggregate-demand oil-price effect, the oil-supply-and-precautionary-demand oil-price effect and the seasonally adjusted (SA) ratio of the federal debt held by the public to GDP. In columns (3) and (4), the dependent variable is the log of the real price-adjusted major dollar index, and the explanatory variables are the global-aggregate-demand oil-price effect, the oil-supply-and-precautionary-demand oil-price effect and the ratio of the federal debt held by the public to GDP.

Dependent Variable/ Short Run	Real Price-Adjusted Broad Dollar Index		Real Price-Adjusted Major Dollar Index	
	(1)1986:1-2007:2 †	(2) 1986:1-2010:4 ††	(3) 1986:1-2007:2 †	(4) 1986:1-2010:4 ††
Global-Aggregate-Demand Oil-Price Effect	-0.1005358*** ***-3.49***	-0.0891803*** ***-4.94***	-0.1124501*** ***-2.81***	-0.0940972*** ***-3.57***
Oil-Supply-and-Precautionary-Demand Oil-Price Effect	-0.0484369*** ***-2.64***	-0.0519323*** ***-3.00***	-0.0499927* ***-1.96***	-0.053301** ***-2.24***
Ratio of SA US Federal Debt held by the Public to GDP	-1.259985*** ***-3.61***	-0.78806*** ***-2.73***		
Ratio of SA US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)		1.36055*** ***2.74***		
Sum of the coefficients on the variables "Ratio of SA US Federal Debt held by the Public to GDP" plus "Ratio of SA US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)"		0.5724904 *1.35*		
Ratio of US Federal Debt held by the Public to GDP			-1.869494*** ***-4.14***	-1.926325*** ***-4.39***
Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)				2.653708*** ***3.61***
Sum of the coefficients on the variables "Ratio of US Federal Debt held by the Public to GDP" plus "Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)"				0.7273829 *1.15*
Adjustment term	-0.3666419+++ ***-4.90***	-0.3670267+++ ***-5.17***	-0.2190446(1) *-3.15*	-0.2301425(2) *-3.47*
Long Run				
Global-Aggregate-Demand Oil-Price Effect	-0.1423562*** ***-5.00***	-0.1314938*** ***-5.77***	-0.1533409** ***-2.21***	-0.1324523** ***-2.52***
Oil-Supply-and-Precautionary-Demand Oil-Price Effect	-0.0705523** ***-2.24***	-0.0816571*** ***-2.70***	-0.0907167 *-1.26*	-0.0803758 *-1.23*
Ratio of SA US Federal Debt held by the Public to GDP	-1.29639*** ***-9.84***	-1.320793*** ***-10.28***		
Ratio of SA US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)		1.018505*** ***4.80***		
Sum of the coefficients on the variables "Ratio of SA US Federal Debt held by the Public to GDP" plus "Ratio of SA US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)"		-0.3022874* ***-1.82***		
Ratio of US Federal Debt held by the Public to GDP			-1.203454*** ***-3.69***	-1.188432*** ***-3.93***
Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)				0.8826661* ***1.81***
Sum of the coefficients on the variables "Ratio of US Federal Debt held by the Public to GDP" plus "Ratio of US Federal Debt held by the Public to GDP multiplied by the financial-crisis Dummy variable (DV)"				-0.3057657 *-0.84*
Constant	1.96081*** ***4.82***	1.96213*** ***5.11***	1.155088*** ***2.96***	1.204406*** ***3.27***
Dummy Variable (equals one from 2007:3 to 2010:4)		-0.1600331*** ***-3.37***		-0.0948199* ***-1.66***
R^2	0.3573	0.4370	0.2840	0.3698
Ramsey RESET test adding the quadratic value of predicted value of the exchange rate variable	t= 0.63(a)	t= -0.61(a)	t= -0.03(a)	t=-0.49(a)
Ramsey RESET test adding the predicted value of the exchange rate variable raised to the powers two, three, and four (F-test)	F(3, 75) = 0.35(a)	F(3, 86) = 0.43(a)	F(3, 75)= 0.37(a)	F(3, 86)= 0.40(a)
Breusch-Godfrey LM test for autocorrelation (AR(1) (Chi-square test)	chi2 = 0.030(b)	chi2 = 0.034(b)	chi2 = 0.051(b)	chi2 =0.010(b)

Data are quarterly. The values of the estimates are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics. The t-statistics for the long-run effects of the variables are computed following the delta method.

(*), (**) and (***) indicate the 10%, 5% and 1% significance levels for the short- and long-run effects of the variables.

(+), (++) and (+++) indicate the 10%, 5% and 1% significance levels for the conclusively non-zero adjustment term using the critical values for the bounds test from table CII in Pesaran et al. (2001). Table CII provides the critical values for the case when there is an intercept, but no trend.

(1) Indicates inconclusive results at 5% and 10% significance levels, and non-rejection of the null hypothesis of no cointegration at 1% significance level.

(2) Indicates inconclusive results at 1%, 5% and 10% significance levels.

(a) Cannot reject the null hypothesis of model has no omitted variables at 5% significance level.

(b) Cannot reject the null hypothesis of no serial correlation at 5% significance level.

Appendices

Appendix 2-1: Data Definitions and Sources

Variable	Source	Units/Remarks
US Real Price-Adjusted Broad Dollar Index and US Real Price-Adjusted Major Dollar Index	Federal Reserve Statistical Release, Summary Measures of the Foreign Exchange Value of the Dollar, Board of Governors of the Federal Reserve System; URL:http://www.federalreserve.gov/releases/h10/summary/indexbc_m.txt Geometric weighted averages of bilateral exchange rates are used to construct the indices. The formulas for the nominal and real indices are represented as follows: $I_t = I_{t-1} \cdot \prod_{j=1}^{N(t)} (e_{j,t}/e_{j,t-1})^{w_{j,t}}$ $RI_t = RI_{t-1} \cdot \prod_{j=1}^{N(t)} \left((e_{j,t} \frac{p_t}{p_{j,t}}) / (e_{j,t-1} \frac{p_{t-1}}{p_{j,t-1}}) \right)^{w_{j,t}}$ I_t is the nominal US dollar exchange rate index at time t I_{t-1} is the nominal US dollar exchange rate index at time $t-1$ $e_{j,t}$ is the price of the US dollar in terms of the foreign currency j at time t $e_{j,t-1}$ is the price of the US dollar in terms of the foreign currency j at time $t-1$ $N(t)$ is the number of currencies in an index at time t p_t is the consumer price index for the US at time t p_{t-1} is the consumer price index for the US at time $t-1$ $p_{j,t}$is the consumer price index for country j at time t $p_{j,t-1}$ is the consumer price index for country j at time $t-1$ $w_{j,t}$ represents the weight of country $j's$ currency where $\sum_j w_{j,t} = 1$ The weights $w_{j,t}$ are calculated using annual data on the international trade between the US and the countries included in the index; hence, it is constant within a calendar year. However, the $N(t)$ and the $w_{j,t}$ are allowed to change over time. The $w_{j,t}$ assigned for each currency implies the importance of the trade competitor. In case inflation in country j is higher than in the US, the real exchange rate index is a better indicator of the US trade competitiveness than the nominal exchange rate index.	-Index -Quarterly averages of monthly data are computed.
WTI monthly	*International Financial Statistics,* International Monetary Fund, Washington D.C..	-US dollars per barrel -Data available are monthly period averages. -Quarterly averages of monthly data are computed.
CPI	*International Financial Statistics,* International Monetary Fund, Washington D.C..	-Index (1970=100) -Data available are monthly

Variable	Source	Units/Remarks
		period averages. -Quarterly averages of monthly data are computed.
WTI Daily	DataStream Note: Data are available starting 10/01/1983.	Crude Oil-WTI Spot Cushing U$/BBL
Brent Daily	DataStream Note: Data are available starting 04/01/1982.	Crude Oil-Brent Cur. Month FOB U$/BBL
Dubai Daily	DataStream Note: Data are available starting 29/01/1986.	Crude Oil-Arab Gulf Dubai FOB U$/BBL
Kilian Index (KI)	Updated version of the index of global real economic activity in industrial commodity markets, proposed in "Not all oil price shocks are alike ...", monthly percent deviations from trend, 1968.1-2011.4; URL: http://www-personal.umich.edu/~lkilian/reaupdate.txt	-Index -Quarterly averages of monthly data are computed.
US Federal Debt held by the public	Federal Reserve Bank of St. Louis (FRED), URL: http://research.stlouisfed.org/fred2/series/FYGFDPUN/	-Millions of Dollars -Monthly data reported for March, June, September and December. --Not Seasonally Adjusted
US GDP	National Income and Product Accounts Table, US Department of Commerce, Bureau of Economic Analysis (BEA). URL: http://www.bea.gov/national/nipaweb/TableView.asp?SelectedTable=5&Freq=Qtr&FirstYear=2007&LastYear=2009	-Billions of dollars -Seasonally adjusted at annual rates -Data are on a quarterly basis which is the lowest frequency available.
Crude Oil Production, World	Monthly Energy Review (July, 2009), Table 11.1b: World Crude Oil Production: Persian Gulf Nations, Non-OPEC, and World. Energy Information Administration; URL:http://www.eia.doe.gov/mer/inter.html	Thousand Barrels per Day
US NFA	U.S. International Transactions Accounts Data, US Department of Commerce, Bureau of Economic Analysis. URL: http://www.bea.gov/international/bp_web/simple.cfm?anon=71&table_id=1&area_id=3 NFA is calculated by subtracting the cumulative value of "Foreign-owned assets in the United States, excluding financial derivatives (increase/financial inflow (+))" from the cumulative value of "U.S.-owned assets abroad, excluding financial derivatives (increase/financial outflow (-))".	-Millions of dollars -Data are on a quarterly basis which is the lowest frequency available.
US Federal Fund Rate (FFR)	*International Financial Statistics,* International Monetary Fund, Washington D.C.	-Percent -Quarterly averages of monthly data are computed.

Variable	Source	Units/Remarks
German Call Money Interest Rate	*International Financial Statistics,* International Monetary Fund, Washington D.C. The German call money rate is "The overnight money rates...applied on the Frankfurt market for interbank loans of 24 hours' duration."[70]	-Percent -Quarterly averages of monthly data are computed.
TED Spread	Source: British Bankers Association and US Federal Reserve.	-Percent -Quarterly averages of monthly data are computed.
	-Updated TED Spread. Source: International Financial Statistics.	-Percent
Volatility Index (VIX)	Chicago Board Options Exchange (CBOE), URL: http://www.cboe.com/micro/vix/historical.aspx "The CBOE Volatility Index (VIX) now is an up-to-the-minute market estimate of expected volatility that is calculated by using real-time S&P 500 Index (SPX) option bid/ask quotes. VIX uses near-term and next-term out-of-the-money SPX options with at least 8 days left to expiration, and then weights them to yield a constant, 30-day measure of the expected volatility of the S&P 500 Index."[71]	-Index -Available starting January 1, 1990 -Quarterly averages of monthly data are computed.
China's imports (Main Land)	*International Financial Statistics,* International Monetary Fund, Washington D.C..	-Million US dollar -Data available are monthly period averages. -Quarterly averages of monthly data are computed.
China's exports (Main Land)	*International Financial Statistics,* International Monetary Fund, Washington D.C..	-Million US dollar -Data available are monthly period averages. -Quarterly averages of monthly data are computed.
The World's imports	*International Financial Statistics,* International Monetary Fund, Washington D.C..	-Billion US dollar -Data available are monthly period averages. -Quarterly averages of monthly data are computed.
The World's exports	*International Financial Statistics,* International Monetary Fund, Washington D.C..	-Billion US dollar -Data available are monthly period averages. -Quarterly averages of monthly data are computed.

[70] Sources and Definitions, Main Economic Indicators, OECD. (n.d). Retrieved from http://stats.oecd.org/mei/default.asp?lang=e&subject=15&country=DEU
[71] New VIX Methodology in 2003, Products, CBOE. (n.d). Retrieved from http://www.cboe.com/micro/VIX/vixintro.aspx#03Method

Appendix 2-2: Additional Variables

To check the robustness of the estimates in Table 2-1, additional variables are added to the model. The first set of additional variables includes macroeconomic variables that previous studies have found to be important determinants of the exchange rate. These variables are the ratio of net foreign assets (NFA) to GDP, and the difference between the US Federal Funds Rate (FFR) and the German call money rate. The second set of additional variables includes variables that reflect risk in the US asset market. These variables are the TED spread (the difference between the three-month LIBOR and the three-month US Treasury bill rate) and the Volatility Index (VIX). The third set includes a variable that reflects China's role in the world economy which is the ratio of China's imports and exports to the world's imports and exports. An overview of the variables in the three sets is presented as follows:

The Set of Macroeconomic Variables

For the likely impact of these variables on the exchange rate, refer to the literature review, Section 2.2.

US Net Foreign Assets to GDP

A measure of US net foreign assets (NFA) can be constructed from data provided by the US Bureau of Economic Analysis (BEA). Following Coudert et al. (2008, p.19), NFA is calculated by subtracting the cumulative value of "Foreign-owned assets in the United States, excluding financial derivatives (increase/financial inflow (+))" from the cumulative value of "U.S.-owned assets abroad, excluding financial derivatives (increase/financial outflow (-))".[72] The ratio of the NFA to GDP is presented in Figure 2-8.

The US NFA-to-GDP ratio may be used to capture the impact of US government debt. However, a better variable than NFA is the ratio of the US federal debt held by the public to GDP. There are two concerns with using the ratio of US NFA to GDP to proxy the exogenous supply of US assets. One is that this variable is hard to calculate and is

[72] In computing their derived external imbalances variable that incorporates a measure of NFA, Alquist and Chinn (2008) interpolate the BEA annual data on US foreign assets and liabilities. Lane and Milesi-Ferretti (2006) provide annual estimates of the foreign assets and liability positions for the US during 1970-2007. Their methodology is based on direct estimates of stocks and indirect estimates of cumulative flows allowing for valuation adjustment.

endogenously determined by foreign and domestic investors' demands for US assets. Second, the NFA value endogenously varies with exchange rate movements.

Interest Rate Differential

The interest rate differential is calculated as the US federal funds rate (FFR) minus the German call money rate. The German interest rate is used as the representative foreign interest rate. The FFR and the German call money rate are viewed as exogenous because they are set by each country's monetary authority. Figure 2-9 depicts the interest rate differential between the US and Germany.

The Set of Variables that Captures the Risk in the US Financial Market

The Ted spread and the Volatility Index (VIX) are added to the model to examine the impact of risk in the US financial crisis. These two variables are explained as follows:

Ted Spread

The TED spread is calculated by subtracting the three-month Treasury yield from the three-month London Interbank Offered Rate (LIBOR). This variable is used to proxy the degree of credit risk in financial markets because Treasury bills are considered risk free whereas the LIBOR incorporates commercial-bank-related credit risk. The TED spread may also signal the degree of investors' confidence in the US financial system, where a decrease in the spread implies a higher degree of confidence.[73] The TED spread is presented in Figure 2-10.

The Volatility Index

The Chicago Board Options Exchange (CBOE) Volatility Index (VIX), presented in Figure 2-11, is a constant 30-day measure of the expected volatility of the Standard and Poor's (S&P) 500 index.[74] The VIX reflects the risk in the US asset market.[75]

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[73] TED spread, Business Dictionary. (n.d). Retrieved from http://www.businessdictionary.com/definition/TED-Spread.html, TED spread, Investors Glossary. (n.d). Retrieved from http://www.investorglossary.com/ted-spread.htm, and Caballero et al. (2008).

[74] New VIX Methodology in 2003, Products, CBOE. (n.d). Retrieved from http://www.cboe.com/micro/VIX/vixintro.aspx#03Method

[75] Note that the data for this variable start in January 1990.

China's Role in the World Economy

The ratio of China's imports and exports to the world's total imports and exports is used as a measure of China's growing role in the world economy. Bénassy-Quéré et al. (2007) argue that China's demand for US goods may differ from other countries, thereby affecting movements in the US dollar. Graphically, this variable has exhibited seasonality that could hinder the analysis. The seasonality effect was confirmed empirically. Hence, the variable is seasonally adjusted by estimating an OLS model where the China variable is regressed on three seasonal dummy variables and a constant, and retrieving the sum of the residuals and estimated intercept. The seasonally adjusted China variable, which is used in the estimation of the model, is depicted in Figure 2-12.

Appendix 2-3: Weak Exogeneity and Granger Causality Tests

If the price of oil and the US dollar cointegrate, they have the error correction form presented by equations (A 2-3- 1) and (A 2-3- 3) (or alternatively equations (A 2-3- 2) and (A 2-3- 4)).

$$\Delta ER_t = a_{10} + \alpha_{ER} ER_{t-i} + \delta_{ER} PO_{t-i} + \sum_{i=1}^{12} a_{11}(i) \Delta ER_{t-i} + \sum_{i=1}^{12} a_{12}(i) \Delta PO_{t-i} + \varepsilon_{ER_t}$$

(Linear Version) A 2-3- 1

$$\Delta ER_t = a_{10} + \alpha_{ER} \left(ER_{t-i} - \frac{\delta_{ER}}{-\alpha_{ER}} PO_{t-i} \right) + \sum_{i=1}^{12} a_{11}(i) \Delta ER_{t-i} + \sum_{i=1}^{12} a_{12}(i) \Delta PO_{t-i} + \varepsilon_{ER_t}$$

(Transformed Version) A 2-3- 2

$$\Delta PO_t = a_{20} + \alpha_{PO} ER_{t-i} + \delta_{PO} PO_{t-i} + \sum_{i=1}^{12} a_{21}(i) \Delta ER_{t-i} + \sum_{i=1}^{12} a_{22}(i) \Delta PO_{t-i} + \varepsilon_{PO_t}$$

(Linear Version) A 2-3- 3

$$\Delta PO_t = a_{20} + \alpha_{PO} \left(ER_{t-i} - \frac{\delta_{PO}}{-\alpha_{PO}} PO_{t-i} \right) + \sum_{i=1}^{12} a_{21}(i) \Delta ER_{t-i} + \sum_{i=1}^{12} a_{22}(i) \Delta PO_{t-i} + \varepsilon_{PO_t}$$

(Transformed Version) A 2-3- 4

A characteristic of cointegrated variables is that discrepancies from long-run equilibrium influence their time paths. If the adjustment terms in both equations (A 2-3- 1) and (A 2-3- 3) are equal to zero, the long-run equilibrium relationship does not exist and "the model is not one of error correction or cointegration" (Enders, 2004, p.329). To carry out inference in a single equation for the exchange rate, the oil price has to be strongly exogenous or at least weakly exogenous. For the price of oil to be strongly exogenous, it has to be weakly exogenous and not Granger caused by the exchange rate (Enders, 2004; and Charemza and Deadman, 1997).

First, testing for weak exogeneity involves testing for the significance of the adjustment terms in the autoregressive equations – presented in equations (A 2-3- 1) and (A 2-3- 3) – for the US dollar and the price of oil. It is possible that either α_{ER} or α_{PO}, but not both, are equal to zero. If $\alpha_{PO} = 0$ and $\alpha_{ER} \neq 0$, the price of oil does not respond to deviations from the long-run equilibrium relationship while the US dollar does respond; accordingly, the price of oil is said to be weakly exogenous. In that case, the US dollar does all the adjustment (Enders, 2004).

For the purpose of testing for weak exogeneity, the linear version of the exchange rate and oil price equations (equations (A 2-3- 1) and (A 2-3- 3)) are the ones individually estimated, allowing for up to 12 lags with monthly data. The SIC is traced to decide on the number of lags to be included. Once the appropriate number of lags is selected for each equation, the significance of α_{ER} in the exchange rate equation and the significance of α_{po} in the oil price equation are tested for.

Second, testing for Granger causality for the cointegrated system presented by equations (A 2-3- 1) and (A 2-3- 3), is carried out by testing for the significance of $a_{21}(i)$ in equation (A 2-3- 3). In case $a_{21}(i) = 0$, oil price movements are not explained by exchange rate movements. In other words, the exchange rate changes do not Granger cause oil price changes.

If $\alpha_{PO} = 0$, the price of oil is weakly exogenous. If $\alpha_{PO} = 0$ and $a_{21}(i) = 0$, the price of oil is weakly exogenous and is not Granger caused by the exchange rate; i.e., it is strongly exogenous. In this case, the ECM is to be estimated with an equation for the US dollar, including no equation for the price of oil (Enders, 2004). In other words, it is appropriate to carry out inference based on a single equation for the exchange rate.

Chapter 3: Competing Hypotheses of the Causes of the US Current Account Deficit

Abstract

The aim of this chapter is to better understand the causes of the increase in the US current account deficit, which is one of the features of global imbalances in the 2000s. I apply a 6x6 Vector Autoregressive (VAR) model to jointly study the impact of China's role in the world economy; global economic expansion; and increases in oil prices, US wealth, and US government debt on the US current account. I study the time sample 1986:1-2010:4, using quarterly data. The reduced form VAR model and Granger causality tests show that US current account movements are directly affected by changes in US government debt and wealth, which are affected by the other three factors. The forecast error variance decomposition of the US current account shows that US wealth and oil-price shocks are most important. The impulse response functions show that the increase in the US government debt did not contribute to the increase in the US current account deficit. As well, in contrast to the "global savings glut" view, the impulse response functions show that an oil-price increase improves the US current account due to the negative effect of an oil-price increase on wealth. This finding shows that an oil-price increase may not be detrimental to the US current account, but may have an unfavourable effect on the overall economy. The results are robust when all or some of the variables are in levels, when simulating the path of the US current account under different scenarios, when using an alternate wealth variable, and when adding a productivity variable.

Keywords: US current account, US government debt, equity prices, oil prices, global economic expansion, China

1 Introduction

The three features of recent global imbalances are the widening of the US current account deficit, current account surpluses in emerging economies and oil exporting countries, and low US and world real long-run interest rates (Bernanke, 2005a and 2007; Caballero et al., 2008b). The US current account deficit is the feature studied in this chapter. Blanchard and Milesi-Ferretti (2009, p.19) state that "it is desirable for savings to go where it is more productive". On the other hand, global imbalances are a problem if they reflect domestic economic distortions. For instance, an increase in private savings could be due to financial repression, while a decrease could be due to a bubble in the asset market and/or overly optimistic expectations. As well, current account deficits could be due to high public sector borrowing (Blanchard and Milesi-Ferretti, 2009). Moreover, large-current-account-deficit countries may have extensive cross-border financial linkages that increase systemic risk associated with disorderly adjustment of global imbalances, including a rapid and sharp US dollar depreciation, higher interest rates and risk premiums, and a decrease in output (Blanchard and Milesi-Ferretti, 2009). Furthermore, a concern regarding global imbalances is whether it is optimal to use low income countries' savings to finance high-income countries' consumption rather than domestic investment (Adams and Park, 2009).

Bernanke (2007) and Caballero et al. (2008b) state that China and oil exporters' savings directed to the US have contributed to the increase in the US current account deficit. The objective of this chapter is to jointly examine the factors behind the widening of the US current account deficit. For that purpose, I apply a vector autoregressive (VAR) model to study the impact of China's role in the world economy and increases in oil prices – possible contributing factors to the global savings glut – in addition to the increase in US wealth, and US government debt on the US current account. The time period studied is 1986:1-2010:4, and quarterly data are used.

The aim is to provide a better understanding of the causes of the increase in the US current account deficit. Pinpointing the cause(s) of the problem and the potential interaction between such causes would help future research in deriving policies to avoid or at least dilute the negative effects of external imbalances. It is of assistance, for instance, in deciding on measures to control the supply of global savings and the reliance of the US on foreign borrowing to finance the saving-investment gap and government debt, as well as the necessity of greater global coordination. This is also important since an idea of possible causes supported by the data is needed to direct further research.

Chinn and Ito (2008) state that the savings glut hypothesis needs further assessment, because the increase in the US current account deficit is attributed, by Bernanke (2007), to the increase in supply of global savings as well as to the US budget deficit. Chinn and Ito (2008) show that excess investment in the US in 1996-2000 and the saving drought in 2001-2004 were behind the US current account deficit, and that the current account surplus in East Asia, starting in 1995, was not due to an increase in savings. Arezki and Hasanov (2009) state that oil exporters' policies contribute to global imbalances as oil prices increase. Kilian et al. (2009) show that oil-price shocks explain 57% of the fluctuations in oil importers' current accounts. As for the wealth effect, Fratzscher and Straub (2010), Fratzscher et al. (2009) and Fratzscher and Straub (2009) find that an asset-price shock, whether an equity-price or a housing-price shock, results in a deterioration of the US current account. Regarding fiscal policy, Chinn and Prasad (2003), Chinn and Ito (2008), and Bussiere et al. (2010) find a positive relationship between the government budget balance and the current account balance, while Kim and Roubini (2008) find a negative relationship. Balakrishnan et al. (2009) state that the ease with which the US current account deficit has been financed is due to an increase in US productivity; however, Chakraborty and Dekle (2009) attribute the increase in the US current account deficit, in the 2000s, to financial liberalization and the decrease in the cost of international borrowing.

Few empirical papers have jointly assessed the factors behind the US current account deficit – as a feature of the 2000s global imbalances – and the interaction between these factors. Chinn and Ito (2008) study the savings glut hypothesis with a focus on China, examining the role of financial development and government budget balance. Bussiere et al. (2010) study the impact of productivity and budget balance; Gruber and Kamin (2007) study the effects of productivity, fiscal balances, economic openness, and financial development; and Chakraborty and Dekle (2009) focus on productivity and the decrease in the cost of international borrowing.

The contribution of Chapter Three is, first, to jointly study the hypotheses behind the increase in the US current account deficit in the 2000s. The hypotheses examined include China's role in the world economy, global economic expansion, the increase in oil prices, US household wealth and US government debt. A VAR model is applied to allow for interaction and feedback effects between the variables, and because the VAR approach is useful when it is not clear which variables are exogenous. The VAR model allows the role of oil prices to be determined, while accounting for the role of US government debt and household wealth, China, and global demand shocks. Second, given the VAR results, the path of the US current account is simulated using a hypothetical oil price series in order to determine the magnitude of the oil-price effect on the US current account. Third, I examine the additional hypothesis that the US current account is driven by shocks to the US-European productivity differential.

The main finding of Chapter Three is that an oil-price increase improves the US current account chiefly by reducing US wealth, as measured by the Standard and Poor's (S&P) equities index. This leads to higher US savings. A higher oil price, by reducing the value of equities and wealth, also leads to higher US government debt. This is shown to reduce the current account deficit, which is in contrast to the "twin deficits" hypothesis, but consistent with Kim and Roubini's (2008) empirical findings for the US. China's role in the world economy affects the US current-account-to-GDP ratio through the real oil price and government debt variables. These findings are supported by the reduced-form VAR, impulse response functions, Granger causality, and forecast error variance decomposition results. These findings are also robust to the inclusion of the US-European productivity differential, and when an alternate wealth variable is used.

The rest of the chapter is organized as follows: The second section provides a chronological description of US current account imbalances starting in the mid-1990s and an overview of the implications of current account deficits. The third section provides a review of the theoretical and empirical literature on each of the hypotheses examined in this chapter. The fourth, fifth, and sixth sections present the hypotheses, methodology, and data, respectively. The seventh and the eighth sections provide the empirical issues and vector autoregressive analysis methods. The ninth and the tenth sections provide the results and the robustness of the results. The eleventh section concludes the chapter.

2 Global Imbalances

The objective of this chapter is to provide a better understanding of the possible reasons behind the increase in the US current account deficit in the 2000s, which is one of the features of recent global imbalances.[76] This section provides a chronological background for the increase in the US current account deficit starting in the mid-1990s. It also provides insight into the importance of the topic of this chapter and its implications.

2.1 A Chronological Background of the US Current Account Deficit

The chronological break-down of the increase in the US current account deficit helps in visualizing the link between the hypotheses postulated in the literature and examined in this chapter. According to Blanchard and Milesi-Ferretti's (2009) chronological break-down of the stages of the global imbalances that led to the US financial crisis, there are three phases. These phases are 1996-2000, 2001-2004 and 2005-2008.

In 1996-2000, despite the financial crises that occurred in Asia and Russia, there was an increase in global economic growth. The optimistic prospects for the US relative to Japan and emerging Asia attracted foreign domestic investment (FDI) and foreign portfolio investment (FPI) to the US. The US current account deficit increased from

[76] The three features of global imbalances, as explained by Bernanke (2005a and 2007) and Caballero et al. (2008b), are the widening of the US current account deficit, the current account surpluses in emerging economies and oil exporting countries, and the low US and world real long run interest rates. This chapter focuses on the US current account.

around 1.5% in 1996 to around 4% in 2000 (Figure 3-1), with the surplus counterpart mainly driven by Japan and emerging Asia (after the crisis). The increase in the US current account deficit reflected the increase in investment at a greater rate than the increase in domestic savings, at a time of high US economic growth (Blanchard and Milesi-Ferretti, 2009, p.19). FDI and FPI driven by the "productivity boom and the dot-com bubble" represented 40% of the capital flows to the US during this period (Blanchard and Milesi-Ferretti, 2009, p.19).

In 2001, the dot-com bubble burst and the advanced economies experienced a recession. As a result, the imbalances narrowed, but increased again in 2002. In 2001-2004, the US remained the major current-account-deficit country, and the major current-account-surplus countries expanded to include oil exporters and Germany. The US current account deficit was associated with deterioration in the US fiscal balance, and a decrease in the US investment and saving rates, where savings decreased at higher rate than investment (Blanchard and Milesi-Ferretti, 2009, p.19). As well, FDI and portfolio equity inflows decreased in importance, and there was an increase in foreign demand for US Treasury securities and corporate bonds (Blanchard and Milesi-Ferretti, 2009, p.20). The share of official foreign demand for US Treasuries amounted to around 20% of total capital inflows and 40% of the current account deficit (Blanchard and Milesi-Ferretti, 2009, p.20). The current account surpluses in Japan, emerging Asia, and Central and Northern Europe reflected a decrease in investment rates whereas the current account surplus in oil exporting countries was due to the increase in saving rates associated with the increase in oil prices (Blanchard and Milesi-Ferretti, 2009).

In 2005-2008, the US and other countries, including South and Central Europe, experienced current account deficits as well as a boom in their asset markets. The current-account-surplus countries, during this period, were China and the oil exporting countries. The current account surplus in China was due to an increase in savings and the current account surplus in oil exporting countries was due to the increase in oil prices (Blanchard and Milesi-Ferretti, 2009). This period was characterized by an expansion in global economic activity and capital movements, where foreign demand for US assets was mainly directed to US Treasury and corporate bonds (Blanchard and Milesi-Ferretti, 2009).

During the first phase of the US financial crisis from July 2007 to June 2008, the increase in the demand for US sound and liquid assets resulted in a bubble in the US asset market (Caballero et al., 2008b, p.3).[77] The crisis was intensified by the shortage of sound and liquid assets in the global economy. The subprime crisis, in July 2007, resulted in a reduction in US wealth, causing consumption to decrease and the trade balance and current account to improve. In July 2008, oil prices collapsed and global aggregate demand dropped. Yet, there was an increase in the demand for US Treasuries due to the flight-to-quality effect.

This chronological background suggests that studying the different hypotheses behind the increase in the US current account separately is not the way to proceed, and that it is important to allow for interaction and feedback effects between the different factors that led to the widening of the US current account deficit (Caballero et al., 2008b).

2.2 Are Large Current Account Deficits An Important Issue?

According to Blanchard and Milesi-Ferretti (2009), there is nothing wrong with large current account deficits. It is normal that current accounts do not balance because it is desirable that capital flows/savings go where they are more productive. However, a large current account deficit is a problem for a number of reasons. First, it is a problem if it reflects domestic economic distortions. For instance, an increase in private savings could be due to financial repression, a decrease in private savings could be due to a boom in the asset market and/or optimistic expectations, and current account deficits could be due to high public sector borrowing (Blanchard and Milesi-Ferretti, 2009).

Second, the larger is a country's current account deficit, the more extensive tend to be cross-border financial links, and the greater is the systemic risk (Blanchard and

[77] The characteristics of a bubble in the asset market are an increase in asset prices, and a decrease in interest rates and risk premia.

Milesi-Ferretti, 2009). Rogoff (2006) explains that the main drivers to adjustment – closing imbalances – are likely to be shocks to "national savings and investment imbalances" (Rogoff, 2006, p.696). He states that faster adjustment would happen if a shock occured, and that a rapid contraction in the US current account deficit would be associated with a large US dollar depreciation. Hence, a large change in the US current account deficit is expected to have an immediate effect on US asset prices that would be extended to the global financial system, affecting world interest rates. As well, if a contraction in US consumption or negative shock to global demand is the driving shock behind the re-balancing, the global demand "re-equilibration" may be painful. The consequential negative effects of US current account adjustment on the world economy would range from an economic slow-down to a recession, depending on the economic conditions prevailing in an economy (Blanchard and Milesi-Ferretti, 2009; and Rogoff, 2006).

Third, the reliance on foreign capital makes a country vulnerable to the volatility of foreign capital flows and sudden stops by foreign investors. This is especially the case when borrowers underestimate liquidity risk. "Foreign lenders may change their mind, leading to sudden stops, which will trigger a painful adjustment, more painful than borrowers anticipated or took into account" (Blanchard and Milesi-Ferretti, 2011, p.5-6). Furthermore, the reliance on foreigners to finance domestic investment and consumption makes the domestic country a hostage of foreign investors' "sentiment" (Blanchard and Milesi-Ferretti, 2009, 15). Fourth, a concern as well is whether it is optimal to use savings of a low-income country to finance high-income countries' consumption instead of the low-income country's domestic investment (Adams and Park, 2009).

In short, the reliance on foreign funds makes a country vulnerable to sudden stops. The disorderly adjustment of global imbalances brings about high risks and costs, including a rapid and sharp depreciation of the US dollar, an increase in interest rates and risk premia, and a decrease in output. The larger the current account deficit, the more the cross-border financial links, and the higher the systemic risk.

3 Different Hypotheses and Potential Causes of the Increase in the US Current Account Deficit

This section provides a theoretical overview followed by a review of the empirical literature for each of the potential causes of the US current account deficit examined in this chapter.

3.1 Fiscal Policy

Frankel (2006) states that the US fiscal expansion during the 2000s caused a budget deficit and a current account deficit. According to Bernanke (2005a and 2007), Summers (2004) and Backus et al. (2009), the low US savings rate, since the late 1990s, was due to the increase in the US federal budget deficit and resulted in US dependence on foreign capital to finance the saving-investment gap. According to national income accounting, the excess of domestic investment over national saving (private and government savings) is equal to the current account deficit and is funded by external borrowing.

The occurrence of a budget deficit and a current account deficit at the same time is a phenomenon referred to as “twin deficits” (Gramlich, 2004). Although this was the case in the US in the mid-1980s and in the first decade of the 2000s, the two deficits went in opposite directions in the 1990s, a phenomenon known as “twin divergence” (Kim and Roubini, 2008, p.364). Kim and Roubini (2008) state that the positive relationship between the budget deficit and the current account deficit, i.e. the twin deficit, does not apply to all time periods for the US economy.

Frenkel and Razin (1996) state that the current account is independent of fiscal policy if consumption is a function of life time income and non-distortionary taxes (that is, if the Ricardian Equivalence hypothesis holds). However, the current account is affected by the budget deficit if consumption is a function of current disposable income (so, the Ricardian Equivalence hypothesis does not hold). Also, the relationship between the fiscal stance and the current account is stronger in countries whose financial systems are more regulated or underdeveloped (Frenkel and Razin, 1996). Moreover, if public debt is low, the existing generation will consider a future debt stabilization policy to be unlikely, and would expect future tax liabilities to be small.[78] In this case, fiscal adjustments would affect aggregate demand and savings. On the other hand, in cases of high public debt, future debt stabilization is more likely to occur and "the debt neutrality is at full force" (Frenkel and Razin, 1996, p.528). In other words, the relationship between fiscal and external deficits may be stronger the smaller is the level of public debt (Frenkel and Razin, 1996).

Issing (2005) reports the findings of empirical research on the impact of the budget balance on the current account in high income countries, where the studies generally examine the period from the 1950s to the 1990s. The general finding for the US is that fiscal policy has contributed to the widening of the US current account deficit. However, fiscal policy only explains a small fraction of the movements in the US current account deficit (Issing, 2005).

Kim and Roubini (2008) apply a VAR model to study the impact of fiscal policy – i.e., government budget deficit shocks – on the US current account and real exchange rate. They study the period 1973–2004 using quarterly data.[79] Their results show that an increase in the government budget deficit results in an improvement in the US current account deficit. The result is attributed to the increase in private savings and the decrease in investment caused by the increased government deficit (Kim and Roubini, 2008). Kim and Roubini (2008) state that the results are in contrast to the theoretical models that show that an expansionary fiscal policy results in a deterioration of the current account. They attribute this finding to the US-economy-specific feature of being a relatively closed large open economy. In such a case, an expansionary fiscal policy would crowd out private investment and stimulate private savings (Kim and Roubini, 2008).

[78] According to Sutherland (1997, p.149) "In order to satisfy its intertemporal budget constraint the government introduces debt stabilisation policies when debt reaches extreme levels. These stabilisation programmes involve large tax rises."
[79] The variables in the basic VAR are the log of real GDP, the ratio of a government budget to GDP, the ratio of the current account to GDP, the three-month (ex-post) real interest rate, and the log of the real exchange rate, respectively.

Chinn and Prasad (2003) apply cross section and panel estimates for a group of 18 industrial countries, which includes the US, and 71 developing countries over the period 1971-1995. Their objective is to study the determinants of current accounts over the medium term. Hence, they use low frequency data, and do not distinguish between the short- and long-run effects.[80] Cross-section results show that the government-budget-balance-to-gross-domestic-product (GDP) variable has a positive and significant impact on the current account across all country groups.[81] The panel estimates show that the government budget balance has a positive and significant impact on the current account across all country groups except for industrial countries where the impact is insignificant.

3.2 US Household Wealth

There are several features of the US economy that allow the US to have a current account deficit for a long time. First, US investors are more inclined to invest in foreign direct investment and risky assets that earn high returns over the long run. On the other hand, US liabilities to foreigners are more weighted towards less risky assets that earn low returns over the long run (Gourinchas and Rey, 2005). Another feature that allows the US to run current account deficits is that the US dollar is widely used in international trade and investment, so most US liabilities are denominated in US dollars. Hence, when the US dollar depreciates, US liabilities are unchanged while the value of the foreign assets owned by US residents increases, causing US wealth to rise. This is a privilege to the US as this valuation channel cushions the impact of current account adjustment (Gourinchas and Rey, 2005).

Bernanke (2005b) states that the endogenous evolution of wealth and expected returns is an important variable in explaining current account dynamics. He explains that the increase in capital flows to the US, driven by the global savings glut, resulted in a decline in real interest rates around the world, causing the value of assets – including

[80] They use annual data, five-year average data and 25-year cross sectional averages.
[81] They study the impact in the case of a full sample, full sample excluding Africa, industrial countries, developing countries, and developing countries excluding Africa.

stocks, houses and land – to increase. Hence, the global savings directed to the US resulted in capital gains to US households in asset markets and an increase in the value of their houses, causing US saving to decrease, which contributed to the US current account deficit.[82] Bernanke (2005b) explains – using a portfolio balance model – that an increase in US wealth causes the US trade balance to deteriorate and hence worsens the US current account. He also finds that, the US dollar depreciates and US foreign debt increases in the long run. He states that smoother current account adjustment is expected when accounting for endogenous wealth dynamics.

Fratzscher and Straub (2010), Fratzscher et al. (2009), and Fratzscher and Straub (2009) use Bayesian structural VAR models with sign restrictions to study the impact of asset-price shocks on the current accounts and trade balances of industrialized countries, including the US. Specifically, Fratzscher et al. (2009) study the impact of equity-price and housing-price shocks on the US trade balance and current account. The US variables are measured in relative terms to those of the Group of Seven (G-7) countries as a proxy for the rest of the world[83]. They find that equity-price and housing-price shocks have been major determinants of the US current account in 1974-2008 using quarterly data. A variance decomposition shows that equity-price and housing-price shocks explain 30% of US trade balance movements at the 20th quarter horizon (Fratzscher et al., 2009). The impulse response functions show that “a 10% rise in US equity prices relative to the rest of the world lowers the US trade balance by around 0.85% of US GDP while the housing-price shock exhibits a slightly larger elasticity” (Fratzscher et al., 2009, p.4). The effects of the shocks are significant in the short and long run, and increase gradually “reaching their peaks after around 3 years” (Fratzscher et al., 2009, p.4). In addition, the response of the current account to the equity-price and

[82] Caballero et al. (2008a) describe the situation as if the bubble in emerging economies in the 1990s moved to the US housing and asset markets.

[83] The variables used are consumption, the price level, the short-run interest rate, the real effective exchange rate, equity prices, nominal housing prices and the trade balance. All variables except for the exchange rate, trade balance and current account are measured in relative terms to the total of the G-7 countries. The US trade balance and current account are measured as ratios of US GDP.

housing-price shocks is bigger than the response of the trade balance to these shocks, and is generally significant in the short run and the long run (Fratzscher et al., 2009).

Fratzscher and Straub (2009) study the impact of equity-price shocks on trade balances of the G-7 countries in 1974-2007 using quarterly data.[84] The US trade balance is found to be more sensitive, relative to the rest of the sample countries, to equity-price shocks. A 10% increase in US equity prices results in a significant decrease in the US trade balance, reaching a maximum of 0.91 of US GDP in the 16th quarter. Fratzscher and Straub (2009) explain that the wealth effect is a channel through which asset prices affect the trade balance. In addition, a 10% increase in US equity prices results in a significant decrease in the US current account. The impact on the US current account is higher than the impact on the US trade balance as the former incorporates the decrease in the trade balance and net foreign assets position. Applying a Choleski decomposition, allowing for all possible orderings of the variables, they find that an equity-price shock has a negative and significant impact on the US trade balance in the long run.

Fratzscher and Straub (2010) extend Fratzscher and Straub's (2009) sample to include 16 industrialized countries. The US trade balance is found to be more sensitive, relative to the rest of the sample countries, to equity-price shocks. A 10% increase in relative US equity prices results in a deterioration of the US trade balance. This effect increases gradually until the 16th to 20th quarters, at which point the US trade balance has decreased by more than 1.2% of US GDP. The impact on the trade balance and the current account is significant in the short run and the long run. Fratzscher and Straub (2010) explain that the importance of the wealth effect, i.e. the financial channel, is higher for countries where asset home bias and households' equity wealth are high, which applies to the US.

[84] For each country, the variables in the VAR are equity prices, consumption, the short-run interest rate, inflation, the real effective exchange rate and the trade balance. All variables except the exchange rate and the trade balance are measured in relative terms to the total of the rest of the sample countries. The trade balance is measured as a ratio of the GDP for each country.

3.3 The Savings Glut Hypothesis

After the East Asian crisis in 1998, there was a change in savings and consumption patterns on a global level. Specifically, there was an increase in savings in emerging economies and oil exporting countries (Bernanke, 2005a and 2007). Due to cross country differences in financial development, and the shortage of sound and liquid assets in these economies, there was a surge in capital flows from emerging economies and oil exporting countries to the US, as well as other industrial countries, in a quest for 'sound and liquid' assets (Caballero et al., 2008b, p.3). The surge in global savings is a situation referred to by Bernanke (2005a and 2007) as the 'savings glut'.

At the same time as the savings glut appeared, the US began to rely on foreign borrowing to finance its budget deficit (Bernanke 2005a and 2007).[85] Consequently, oil exporting countries and emerging economies became net lenders, and the US absorbed the increase in global savings (Arezki and Hasanov, 2009; Meredith, 2007; and Bernanke, 2007). The outcome was a current account surplus in emerging economies and oil exporting countries, and an increase in the US current account deficit.

Bernanke (2007) states that the increase in oil exporters' savings was due to the surge in oil prices that resulted in an increase in their income beyond their capacity to increase spending. This is consistent with the Krugman (1980) and Bénassy-Quéré et al. (2007) portfolio balance models that show that consumption by oil exporters responds to an oil price increase with a lag. Hence, a rise in oil prices results in an increase in oil exporters' demand for foreign assets in the short run.

As for China, Bernanke (2007) and Caballero et al. (2008b) attribute the increase in precautionary savings to the increase in economic growth accompanied by an underdeveloped financial sector. Sun (2010) also shows that productivity growth can

[85] In the 2007 monetary policy report to the Congress, it is reported that there was an improvement in the private business, and state and local government saving rate (Board of Governors of Federal Reserve, February 2007). However, the decrease in the household saving rate offsets this increase. Generally, this was seen as an improvement for US national savings, yet it was not enough to avoid the dependence on foreign borrowing (Board of Governors of Federal Reserve, February 2007).

lead to an increase in savings and this contributed to the savings glut in East Asian countries.

Chinn and Ito (2008) apply panel analysis for 19 industrial countries and 69 developing countries for the period 1971-2004 to explain global current account imbalances and to assess the savings glut hypothesis. They use non-overlapping five-year averages to focus their analysis on medium-term rather than the short-term changes in the current account. Chinn and Ito (2008) find that the government budget balance has a significant and positive effect on the current account balance for industrialized countries. Chinn and Ito (2008) also applied pooled regression techniques and augmented their model with legal development and financial openness variables as well as interactive variables between legal development and financial development, and between financial openness and financial development.[86] With these changes, they continued to find a positive and significant relationship between the government budget balance and current account balance for industrialized countries. They also find that, financial development in emerging Asia neither results in a decrease in saving rates nor affects current account balances in Asia (Chinn and Ito, 2008). Their augmented model is also used to make out-of-sample predictions of savings and investment for the US and emerging East Asia, excluding China. The results show that the US current account deficit was due to "more than-expected performance in investment" in 1996-2000 and due to a "saving drought" in 2001-2004, while the current account surplus in East Asia, starting in 1995, was due to a decrease in investment rather than an increase in savings (Chinn and Ito, 2008, p.491).

Arezki and Hasanov (2009) state that oil exporters' fiscal expenditure as well as the allocation of accumulated petrodollars of sovereign wealth funds (SWFs) could either intensify or alleviate global imbalances. Applying pooled OLS, fixed effects and generalized method of moments (GMM) to study current account movements for oil

[86] The reason is that legal and institutional development reflects the extent to which returns from private saving and investment are protected (Chinn and Ito, 2008).

exporters and the rest of the world in 1980-2007, Arezki and Hasanov (2009) find that oil exporters' fiscal policy has a significant impact on global imbalances.[87]

Bernanke (2007), Caballero et al. (2008b) and Arezki and Hasanov (2009) argue that oil exporters contributed to global imbalances. However, Balakrishnan et al. (2009) note that oil exporters' holdings of US assets are relatively small and hard to track. In this context, it is important to mention that, after the financial chaos in 2007, official foreign inflows were the main source of financial flows and were principally directed from Asian central banks (Board of Governors of Federal Reserve, February 2009, July 2008, July 2007 and February 2007).

3.4 Oil Prices and the US Trade Balance

From the portfolio balance models in Chapter One as well as Krugman (1980) and Bénassy-Quéré et al. (2007), in the short run, an increase in the price of oil is associated with an increase in oil exporters' demand for foreign assets. In the long run, oil exporters' consumption will adjust to match the increase in oil revenues. This description of the response of oil exporters' consumption is not inconsistent with oil exporters' economic behaviour in the first decade of the 2000s. Bernanke (2007) and Caballero et al. (2008b) explain that the increase in oil exporters' oil revenues was beyond their capacity and willingness to spend. Hence, in the short run, the increase in the price of oil is associated with an increase in the value of US oil imports without an equivalent increase in the volume of US exports to oil exporters. As a result, the US trade balance with oil exporters deteriorates. This effect is larger if oil exporters have a greater preference for non-US goods and the US demand for oil is highly price inelastic.[88] In the long run, the change in the US trade balance with oil exporters will continue to be influenced by oil exporters' preferences and the US price elasticity of demand for oil.

Empirically, Kilian et al. (2009) apply the Kilian (2009b) approach to study the impact of three distinct types of oil-price shocks – an oil-supply-disruption shock, a

[87] They use annual data for 21 oil exporting countries and 115 countries, other than the oil exporting countries, to represent the rest of the world.
[88] Evidence in Hamilton (2010) suggests the US price elasticity of demand for petroleum is very small.

precautionary-demand-oil-price shock and a global-aggregate-demand-oil-price shock – on external balances of oil exporters and oil importers during the period 1975-2006. Variance decomposition results for oil importers show that oil-price shocks explain around 57% of their current-account fluctuations and 75% of their trade-balance fluctuations. Impulse response function results for oil importers show that the precautionary-demand-oil-price shock has a negative, small and significant impact on the current account in the short run. In the long run, the impact is insignificant and tends to zero.

Kilian et al. (2007, p.14) find that a precautionary-demand-oil-price shock has an immediate, significant, persistent and negative impact on the oil trade balance for high-income oil-importing economies (the US, Euro Area, and Japan), and a global-aggregate-demand-oil-price shock has a delayed, significant and negative impact on their oil trade balances. The impact of these two shocks on the US oil trade balance is small relative to that on the Euro Area and Japan. On the other hand, non-oil trade balances of this country-group do not deteriorate due to positive oil-price shocks. An oil-supply-disruption shock has a positive and significant impact on the Euro Area non-oil trade balance, and an insignificant impact on the US non-oil trade balance and Japan's non-oil trade balance. Interestingly, a global-aggregate-demand-oil-price shock has a positive, delayed, and significant impact on the US non-oil trade balance, but not on that of the Euro Area and Japan. A precautionary-demand-oil-price shock has a positive, significant and delayed impact on the US, the Euro Area and Japan's non-oil trade balances; although the impact on the Euro Area is relatively smaller.[89] The overall effect of a global-aggregate-demand-oil-price shock on the US trade balance is an initial deficit followed by a significant surplus after three years. Generally, a precautionary-demand-oil-price shock has a positive effect on the US trade balance.

[89] Kilian et al. (2007) explain that the response of the US non-oil trade balance to oil-price shocks is consistent with the response of US GDP to such shocks, as an increase in oil prices causes GDP to decrease, and accordingly the non-oil trade balance improves.

3.5 Productivity

Balakrishnan et al. (2009) attribute the ease with which the US current account deficit has been financed, during the first decade of the 2000s, to an increase in US productivity. The external debt stability condition derived by Gramlich (2004) reflects the importance of economic growth and productivity in sustaining a current account deficit. Gramlich (2004) argues that an economy with outstanding debt would be able to run primary deficits if the growth rate is high enough to prevent the debt-to-GDP ratio from increasing (Gramlich, 2004). This shows that economic growth and productivity are integral to the analysis.

Theoretically, Frenkel and Razin (1996) apply an intertemporal approach to analyze the dynamics of the current account. They find that a permanent country-specific productivity shock causes an increase in current investment. As well, current consumption increases due to the increase in expected future investment that results in a rise in the future capital stock and future income. In such a case, permanent income and current consumption increase by more than the increase in current income. Hence, a permanent country-specific productivity shock has a negative impact on a country's current account due to both the rise in investment and a fall in savings. In the case of a transitory country-specific productivity shock, investment is not affected. The change in wealth is equal to the transitory increase in current income, and future expected income is unchanged. Hence, the change in current consumption is smaller than in the case of a permanent country-specific shock, and the impact of the shock on the current account is expected to be positive since saving is positive.

In the 1980s and the first decade of the 2000s, the US current account and budget balance were in deficit, satisfying the twin deficit hypothesis; however, this was not the case in the 1990s (Bussiere et al., 2010). The increase in US productivity, rather than fiscal policy, is considered the main determinant of current account movements in the 1990s, whereas fiscal policy is considered the determinant of current account movements in the 1980s and the first decade of the 2000s (Bussiere et al., 2010).

Bussiere et al. (2010) study the role of productivity and budget balance, jointly, as determinants of current account movements. They use an intertemporal model for the current account that includes non-Ricardian behaviour in order to allow for the effect of the budget deficit. Theoretically, this is carried out by assuming that a fraction of consumers follows Ricardian behaviour, i.e., savers who smooth resources intertemporally, while the other fraction follows non-Ricardian behaviour, i.e., spenders who rely on disposable income. Empirically, they apply panel analysis to study the joint behaviour of the current account and investment for a panel of 21 Organization for Economic Co-operation and Development (OECD) countries over the period 1960-2003 using annual data. Their results show, theoretically and empirically, that a positive country-specific productivity shock and a negative primary-government-balance shock lower the current account balance.

Gruber and Kamin (2007) apply a panel regression to 61 countries during the period 1982-2003 to examine a number of hypotheses put forward in the literature to explain the increase in the US current account deficit and the current account surplus in Asia. They use the growth rate in real per-capita income to proxy productivity growth. Gruber and Kamin (2007) find that the standard variables used to explain current account movements – per-capita income, output growth, fiscal balances, net foreign assets, economic openness and demographics – do not explain the US current account deficit and the large current account surpluses in developing Asia since the late 1990s. They include additional variables to account for the occurrence of a financial crisis, the quality of government institutions and the level of financial development to reflect the attractiveness of the of the US financial sector. However, the model still cannot explain the increase in the US current account deficit.

Chakraborty and Dekle (2009) state that the increase in US productivity, since the mid-1990s, caused the relative increase in returns on capital in the US at a time when productivity in Europe and Japan had stagnated. As a result, there was an increase in capital flows from Europe and Japan in search of higher returns on capital in the US, which contributed to the US current account deficit. However, they find that the productivity gap hypothesis cannot account for the increase in the US current account deficit since 2000. Chakraborty and Dekle (2009) calculate total factor productivity (TFP) for the US versus two sets of countries/regions: Europe and Japan; and Europe, Japan and Emerging Asia. These calculations reveal that US productivity growth exceeded that of the rest of the world in 1991-2000. However, since 2000 US productivity growth has lagged relative to the rest of the world because of the increase in TFP growth in emerging Asia, especially China (Chakraborty and Dekle, 2009). Chakraborty and Dekle (2009) explain that if the productivity gap hypothesis is valid, the US should have experienced capital outflows and a decrease in the current account deficit in the first decade of the 2000s, which is in contrast to what happened.

Chakraborty and Dekle (2009) apply a two-region dynamic stochastic general equilibrium (DSGE) model for the period 1980-2003 to study the determinants of the US current account deficit despite relatively low productivity in the 1980s and the first decade of the 2000s.[90] Their goal is to examine the impact of the productivity growth gap on global imbalances, allowing for the increase in asset market integration. Therefore, costs to international lending are incorporated in the model to capture the comparative difficulty in accessing foreign financial markets due to international and domestic restrictions, such as exchange rate controls and minimum capital requirements. A decrease in this cost indicates a decrease in restrictions on accessing foreign financial markets, causing households to be able to buy foreign bonds at lower costs (Chakraborty and Dekle, 2009).

Chakraborty and Dekle (2009) simulations show that a 1% positive relative US productivity shock causes interest rates to increase, capital inflows to the US to rise, and the US current account to deteriorate. Their simulations also show that a 1% decrease in the cost of international lending causes global interest rates to decrease, capital inflows

[90] The case of the US running a current account deficit despite lagging productivity growth relative to Europe and Japan also occurred in the 1980s.

to the US to increase, and the US current account to deteriorate. Chakraborty and Dekle (2009) explain that a productivity shock that causes the US current account deficit to increase would be associated with an increase in global interest rates. However, "the US real interest rates have actually fallen from about 4.5% in 2000 to about 1.8% in 2005" (Chakraborty and Dekle, 2009, p.679). Hence, they attribute the increase in the US current account deficit in the first decade of the 2000s to financial liberalization, i.e., a decrease in the cost of international borrowing, rather than to the increase in US productivity (Chakraborty and Dekle, 2009).

Balakrishnan et al. (2009) state that, since the US current account deficit was financed by fixed-income instruments for which demand is not affected by "growth prospect", it is likely that there are other factors in addition to US productivity growth that contributed to the increase in the US current account deficit. Using an international capital asset pricing model (ICAPM), Balakrishnan et al. (2009) explain that, theoretically, an increase in the US external debt would result in an increase in borrowing costs. However, this did not happen in the 2000s and they attribute this, through the ICAPM, to a decrease in home bias, the savings glut, and financial innovation. Financial innovation can also lead to an autonomous increase in the demand for US assets which causes foreign investors to re-allocate their capital invested abroad to the US without causing home bias to decrease (Balakrishnan et al., 2009).

3.6 Summary

The literature provides a number of hypotheses relating to the increase in the US current account deficit. These hypotheses are the increase in US government debt, asset prices, and the global supply of savings, particularly by China and oil exporters. Although some economists attribute the ease with which the US current account was financed, in the first decade of the 2000s, to the increase in US productivity growth, others attribute this to financial liberalization and the decrease in the cost of international borrowing. This sub-section provides a summary of the literature review presented in this section.

Regarding fiscal policy, theoretically, as the percentage of population that follows non-Ricardian behaviour increases, it is more likely that the current account is affected by the budget deficit. The less regulated the financial system and the higher the public debt, the weaker the relationship between the government budget balance and the current account (Frenkel and Razin, 1996; and Bussiere et al., 2010). Empirically, Chinn and Prasad (2003), Chinn and Ito (2008), and Bussiere et al. (2010) find a positive relationship between the government budget balance and current account (implying that the twin deficit hypothesis holds), while Kim and Roubini (2008) find a negative relationship.

As for the wealth effect, Bernanke (2005b) states that the savings glut resulted in a decrease in global interest rates, causing asset prices to increase in the US. As a result, US savings decreased and the US current account deficit increased. Empirically, Fratzscher and Straub (2010), Fratzscher et al. (2009), and Fratzscher and Straub (2009) find that an asset-price shock, whether an equity-price or a housing-price shock, results in the deterioration of the US trade balance and current account balance, where the impact on the latter is higher. This negative impact is generally significant in the short and long run.

The Bernanke (2007) savings glut hypothesis attributes the increase in oil exporters' savings to the increase in oil prices, and the increase in China's savings to an increase in precautionary savings (Bernanke, 2007 and Sun, 2010). Chinn and Ito (2008) show that excess investment in the US in 1996-2000 and the savings drought in 2001-2004 were behind the US current account deficit, and the current account surplus in East Asia, starting in 1995, was due to a decrease in investment rather than an increase in savings.

Arezki and Hasanov (2009) find that, as oil prices increase, oil exporters' fiscal policies contribute significantly to global imbalances. Kilian et al. (2009) show that oil-price shocks explain 57% of the fluctuations in oil-importers' current accounts. Impulse response function results show that a precautionary-demand-oil-price shock has a negative, small and significant impact on oil-importers' current accounts in the short run. In the long run, the impact is insignificant. On the other hand, Kilian et al. (2007) find that global-aggregate-demand and precautionary-demand oil-price shocks cause the US non-oil trade balance, net foreign asset position and current account to improve, while the valuation-effect tends to decrease the impact of oil-price shocks on the US and oil-exporting countries.

Regarding the productivity hypothesis, theoretically, a transitory country-specific productivity shock has a positive impact on the current account, while a permanent shock has a negative impact. Empirically, Bussiere et al. (2010) find that a positive productivity shock has a negative impact on the current account. Chakraborty and Dekle (2009) show that the US current account deficit in the first decade of the 2000s is due to financial liberalization and the decrease in the cost of international borrowing, not to an increase in productivity. As well, Balakrishnan et al. (2009) reject the hypothesis that US productivity growth explains the increase in the US current account deficit during the 2000s because capital flows to the US were directed to fixed-income instruments that are not affected by growth prospects. Balakrishnan et al. (2009) attribute the increase in capital flows to the US to the global savings glut, the decrease in home bias in industrial countries, the decrease in the cost of international financial transactions, and financial deregulation.

Balakrishnan et al. (2009) assert that the joint examination of the different hypotheses put forward as explanations of the widening of the US current account deficit during the first decade of the 2000s is important. Few papers jointly examine these hypotheses. Chinn and Ito (2008) study the savings glut hypothesis, and account for financial development and the government budget balance. In studying the productivity hypothesis, Bussiere et al. (2010) account for the budget balance; Chakraborty and Dekle (2009) account for financial liberalization; and Gruber and Kamin (2007) account for fiscal balances, economic openness, and financial development.

In what follows, the hypotheses examined in this chapter are outlined. The hypotheses examined are, particularly, based on Bernanke (2005b and 2007), Caballero et al. (2008b), Fratzscher and Straub (2010), Kilian (2009b), and Kilian et al. (2007).

4 The Hypotheses Examined

Following the literature discussed above, I examine the impact on the US current account of variables that represent China's role in the world economy, global economic expansion, oil prices, US wealth, and US government debt. This allows me to distinguish the role of oil exporters as well as the policy and economic characteristics of the US and China in explaining the increase in the US current account deficit. In this chapter, I examine six hypotheses with respect to the determinants of the US current account.

Under the first hypothesis, an increase in global demand, driven by China's increased role in the world economy, resulted in an increase in the price of oil. An index developed by Kilian (2009b) – referred to hereafter as Kilian Index (KI) – captures the increase in global demand for industrial commodities that is due to the increase in global real economic activity.[91] Kilian et al. (2009) state that the advantage of KI is that it captures the recent increase in emerging economies' – particularly, China and India – demand for industrial commodities. Hence, the China variable – represented by the ratio of China's imports and exports to world imports and exports – would affect KI positively. Kilian (2009a and 2009b) finds that the increase in oil prices in the first decade of the 2000s is due to global economic expansion; hence, KI would affect the real oil price positively. The increase in China's demand for oil causes oil prices to increase, and reflects the high oil intensity of China's production and the impact on oil prices (Bénassy-Quéré et al., 2007). Therefore, the China variable would affect the real oil price positively.

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[91] The view that oil-price shocks prior to the 2007/2008 oil-price shock were mainly due to oil supply disruptions is supported by Hamilton (2009) although Kilian (2009a) argues against this view. However, there is a general agreement that the 2007/2008 shock was due to a surge in global economic growth and demand. Hamilton (2009) states the recent shock was caused by the increase in demand for crude oil – caused by the increase in global economic growth – accompanied by the stagnation in crude oil production. Kilian (2009a and 2009b) finds that the positive global aggregate demand shock is the engine for the 2002-2008 surge in oil prices and that oil supply disruption had no role.

The savings glut hypothesis suggests that the increase in oil prices and China's entry into world trade resulted in an increase in global savings. The latter raised the demand for assets, causing capital gains in the stock market for US residents, and hence an increase in US residents' wealth, a decrease in US savings, and an increase in the US current account deficit (Bernanke 2005b, p.52).

The second hypothesis involves the impact of the real price of oil and the China variable on the wealth variable. The increase in the China variable would be associated with an increase in global economic expansion, as mentioned above. Accordingly, the China variable would be expected to affect the US stock market, i.e., the wealth variable, positively.

Kilian (2009b) disentangles oil price movements into three distinct types of oil-price shocks.[92] Kilian and Park (2009) study the impact of these demand and supply induced oil-price shocks on the US stock market. They find that an oil-supply-disruption shock does not affect US stock returns, while the precautionary-demand oil-price shock has a negative impact on stock prices. The global-aggregate-demand oil-price shock has a positive short-run impact on the stock returns and a negative long-run effect. The short-run impact of the global-aggregate-demand shock is positive due to the stimulus effect of the increase in global economic activity on the US economy, while the long-run negative effect is because the global-aggregate-demand shock causes oil prices to increase and hence slows the US economy. The "resilient" (Kilian and Park, 2009, P.1268) increase in oil prices during the early 2000s was due to the "strong global demand for industrial commodities" (Kilian and Park, 2009, P.1268). "As long as that stimulus persists and there are no major precautionary demand shocks or adverse supply shocks, oil price increases do not necessarily constitute a reason for stock prices to fall. Only in the long run would one expect stock prices to decline" (Kilian and Park, 2009,

[92] The three shocks are oil-supply disruption, global-aggregate-demand, and precautionary-demand shocks. The precautionary-demand shock captures uncertainty regarding oil supply disruptions relative to expected demand (Kilian, 2009b). The time of occurrence and direction of this shock, according to Kilian (2009b), are in harmony with exogenous events that would cause uncertainty about the expected oil supply, such as wars.

p.1277). Thus, the effect of the real price of oil on the wealth variable will likely depend on the type of shock driving the oil-price changes.

The third hypothesis involves the impact of the wealth variable on the US current account. The increase in wealth has a negative effect on the current account balance. The increase in US residents' gains in the capital market, as explained by Bernanke (2005b), caused US residents to feel wealthier and to increase their consumption in the early 2000s. The US demand for foreign goods is high (Blanchard et al., 2005). Hence, the increase in US wealth could result in trade-balance deterioration.

Fourth, as for the impact of the China variable on the US current account, if growing Chinese exports are very competitive in the US market, possibly due to an undervalued currency, expansion of China's trade could cause the US trade balance to deteriorate, contributing to the US current account deficit. Blanchard et al. (2005, p.30) comment on the effect of pegging China's currency to the US dollar that "Pegging leads to a steady increase in US net debt and a steady increase in the foreign central bank's reserves...". In short, the China variable could be expected to have a direct negative effect on the US current account.

Fifth, Kilian et al. (2007) find that the precautionary-demand and global-aggregate-demand oil-price shocks improve the US non-trade balance, the overall US trade balance, the US net foreign asset position and US current account. In addition, following from Chapters One and Two, the increase in the price of oil has a negative impact on the US dollar (implying a depreciation) in the short and long run. The depreciation of the US dollar improves the US trade balance and US net foreign debt; and, hence, the US current account. In short, the real price of oil variable could affect the US current account positively, depending on the magnitude of US oil imports compared to other countries, and the extent of exchange rate effects on goods and asset prices.

Sixth, a negative impact of the US government debt on the US current account indicates the occurrence of twin deficits (Frenkel and Razin, 1996; Bussiere et al., 2010), while a positive impact (a rise in the current account balance when US government debt rises) indicates a "twin divergence" (Kim and Roubini, 2008, p.364).

5 Empirical Methodology

5.1 Vector Autoregressive Models

The objective of this chapter is to jointly study the factors behind the increase in the US current account. Hence, I apply a VAR model to jointly examine the variables of interest and to allow for interaction and feedback effects between these variables. When it is not clear which variables are exogenous, the VAR model is useful because it allows all variables to be treated "symmetrically" (Enders, 2004, p.264) and allows for feedback effects between the variables (Enders, 2004). According to Richards (2005), the VAR model is useful in analyzing and forecasting the dynamic behaviour of economic variables.

Enders (2004, p.270) states "that the goal of a VAR analysis is to determine the interrelationships among the variables, not to determine the parameter estimates." The VAR is employed to provide structural inference and analyses. These structural analyses are based on causal relationships between the variables, where the decision to examine a particular causal relationship is based on theory and/or hypotheses of interest, such as those described in the previous section. The analyses are described by the use of impulse response functions (IRF), forecast error variance decomposition (FEVD) and Granger causality tests (Richards, 2005).

5.1.1 Reduced and Structural Vector Autoregressive Models

To show the link between structural and reduced form VAR models, without loss of generality, a first-order structural 3x3 VAR model is used for illustration in this sub-section. The three variables are y_{1t}, y_{2t} and y_{3t}, where the structural VAR model is presented as follows:

$$y_{1t} = b_{10} - b_{12}y_{2t} - b_{13}y_{3t} + \gamma_{11}y_{1t-1} + \gamma_{12}y_{2t-1} + \gamma_{13}y_{3t-1} + \varepsilon_{y_{1t}}\ , \qquad 1$$

$$y_{2t} = b_{20} - b_{21}y_{1t} - b_{23}y_{3t} + \gamma_{21}y_{1t-1} + \gamma_{22}y_{2t-1} + \gamma_{23}y_{3t-1} + \varepsilon_{y_{2t}}\ , \qquad 2$$

$$y_{3t} = b_{30} - b_{31}y_{1t} - b_{32}y_{2t} + \gamma_{31}y_{1t-1} + \gamma_{32}y_{2t-1} + \gamma_{33}y_{3t-1} + \varepsilon_{y_{3t}}\ . \qquad 3$$

Equations (1-3) can be presented in matrix form as follows:

$$\begin{bmatrix} 1 & b_{12} & b_{13} \\ b_{21} & 1 & b_{23} \\ b_{31} & b_{32} & 1 \end{bmatrix} \begin{bmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \\ b_{30} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \\ y_{3t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{y_{1t}} \\ \varepsilon_{y_{2t}} \\ \varepsilon_{y_{3t}} \end{bmatrix}, \quad 4$$

which can be written more compactly as:

$$\beta Y_t = \tau_0 + \tau_1 Y_{t-1} + \varepsilon_t. \quad 5$$

The term ε_t is the vector of the structural shocks, which are white noise disturbances. They are uncorrelated and have standard deviations of $\sigma_{y_{1t}}$, $\sigma_{y_{2t}}$ and $\sigma_{y_{3t}}$.

In a structural VAR model, each variable is specified to be a function of the other variables in the model as well as the lagged values of itself and of the other variables. This means that all the elements in β cannot be identified without further restrictions. However, the reduced form VAR can be estimated and the reduced form parameters can be identified.

Pre-multiplying equation (5) by β^{-1} yields the reduced form VAR:

$$Y_t = A_0 + A_1 Y_{t-1} + e_t, \quad 6$$

where e_t is the vector of reduced-from residuals, so e_t = $\beta^{-1}\varepsilon_t$, A_0 = $\beta^{-1}\tau_0$, and A_1 = $\beta^{-1}\tau_1$.

Equation (6) implies the three equations:

$$y_{1t} = a_{10} + a_{11}y_{1t-1} + a_{12}y_{2t-1} + a_{13}y_{3t-1} + e_{y_{1t}}, \quad 7$$

$$y_{2t} = a_{20} + a_{21}y_{1t-1} + a_{22}y_{2t-1} + a_{23}y_{3t-1} + e_{y_{2t}}, \quad 8$$

$$y_{3t} = a_{30} + a_{31}y_{1t-1} + a_{32}y_{2t-1} + a_{33}y_{3t-1} + e_{y_{3t}}. \quad 9$$

Hence, there are 12 coefficients to be estimated in the reduced form model. In addition, there are three variances and three covariances, for a total of 18 parameters. This contrasts with the structural model equations in which there are 18 coefficients and three variances for a total of 21 parameters. In order to retrieve the structural parameters from the reduced form estimates, it is necessary to impose three restrictions on the structural parameters. These restrictions can be motivated by the theory and/or hypotheses of interest. The restrictions imposed, based on the hypotheses of interest, in this Chapter are outlined in the following sub-section.

5.2 Causal Ordering to Examine the Hypotheses of Interest in This Chapter

The hypotheses examined in this chapter involve studying the relationship between the US current account, US government debt, wealth, oil prices, global aggregate demand and China's entry into the world economy. Therefore, a 6x6 VAR model is estimated. Without loss of generality, a first-order VAR model is used for illustration in this sub-section. Since there are six variables, 15 restrictions are needed for the structural VAR model to be identified and to retrieve the structural residuals from the reduced form residuals to carry out the structural analyses. These restrictions are imposed by assuming a causal ordering of the variables. The ordering reflects the following assumptions:

1. The China variable does not respond within a quarter to changes in any of the other variables. I assume China's exporters and importers require time to implement changes in production, so they do not adjust within one quarter to changes in the other variables.
2. KI, the global demand variable, is assumed to not respond within a quarter to changes in any variable except for changes in the China variable, since Kilian (2009) finds, while oil prices affect shipping freight rates, this occurs with a delay.
3. Oil prices respond within a quarter to changes in KI and the China variable, but not to the other variables. This follows from the view that oil producers, like Saudi Arabia, do not react within a quarter by changing production levels following an oil demand shock.
4. Wealth does not respond within a quarter to changes in US government debt and tthe US current account, but responds within a quarter to changes in oil prices, KI and the China variable. US financial wealth would be expected to respond quickly to oil price changes, but given the decreasing role of the US economy as a shaper of the world

economy, the wealth effect from the US economy on world demand for oil would be expected to be small within one quarter.

5. US government debt responds within a quarter to changes in all variables except the US current account. This follows since changes in government spending require policy changes or, in the case of income tax changes, require income changes, and these are assumed to take at least a quarter to have an impact.
6. The US current account responds within a quarter to changes in all five of the other variables.

Given these ordering restrictions, the VAR can be written explicitly as:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 & 0 \\ b_{61} & b_{62} & b_{63} & b_{64} & b_{65} & 1 \end{bmatrix} \begin{bmatrix} CHINA_t \\ KI_t \\ PO_t \\ WEALTH_t \\ PD_t \\ CA_t \end{bmatrix} =$$

$$\begin{bmatrix} b_{10} \\ b_{20} \\ b_{30} \\ b_{40} \\ b_{50} \\ b_{60} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} & \gamma_{16} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} & \gamma_{26} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} & \gamma_{35} & \gamma_{36} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} & \gamma_{46} \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & \gamma_{54} & \gamma_{55} & \gamma_{56} \\ \gamma_{61} & \gamma_{62} & \gamma_{63} & \gamma_{64} & \gamma_{65} & \gamma_{66} \end{bmatrix} \begin{bmatrix} CHINA_{t-1} \\ KI_{t-1} \\ PO_{t-1} \\ WEALTH_{t-1} \\ PD_{t-1} \\ CA_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{CHINA_t} \\ \varepsilon_{KI_t} \\ \varepsilon_{PO_t} \\ \varepsilon_{WEALTH_t} \\ \varepsilon_{PD_t} \\ \varepsilon_{CA_t} \end{bmatrix} \qquad 10,$$

where $CHINA_t$ is the share of China's exports and imports in world trade, KI_t is the Kilian Index (KI), PO_t is the price of oil, $WEALTH_t$ is the wealth variable, PD_t is the government debt variable, and CA_t is the US current account variable.

6 Data

The first sub-section below discusses the selection of the time period studied in this chapter. The second sub-section describes the variables used in the estimation.

6.1 Time Period

In this chapter, I study the time period 1986:1 to 2010:4. It is useful to start the time period in the mid-1980s for two reasons. First, the oil market, the exchange rate market, and the US current account experienced substantial changes in the mid-1980s. The year 1986 is closely related to a change in the pricing strategy of the Organization of Petroleum Exporting Countries (OPEC) cartel and is often seen in the literature as a point of structural break in the world oil market (Peersman and Robays, 2009; and Singer, 1987).[93] Also, Peersman and Robays (2009) report a break in oil market dynamics in the first quarter of 1986, after which the dynamics remain stable.

By the mid-1980s, the strong US dollar induced the group of five (G-5) countries (France, West Germany, Japan, the US and the UK) to pursue a coordinated policy, beginning in September 1985, to decrease the value of the US dollar against major foreign currencies (Mishkin, 1997). By the beginning of 1987, the US dollar had decreased in value, on average, by 35% relative to the other currencies (Mishkin, 1997). In addition, since the mid-1980s, the US current account deficit became substantial and the US savings rate began to trend downward (Matsubayashi, 2005).

Second, Obstfeld and Rogoff (2005) argue that the early 1970s is more similar to the first decade of the 2000s than is the 1980s with regard to the increase in the US current account deficit, US fiscal policy, US monetary policy, US dollar movements and oil prices.[94] However, a log likelihood ratio test shows that it is not valid to restrict the coefficients in the VAR models for the periods 1986:1-2010:4 and 1970:1-1985:4 to be the same across the whole period 1970:1-2010:4.[95] Hence, for all these reasons, I restrict the sample to the period 1986:1-2010:4.

[93] Griffin and Neilson (1994) argue that the pricing strategy of oil in the 1970s and early 1980s is different. Saudi Arabia enforced the cartel cohesion via a "swing producer" strategy during the period 1983:03 to 1985:08. Afterwards, Saudi Arabia followed a "tit-for-tat" strategy. Under the "swing producer" strategy, Saudi Arabia adjusts its oil production to stabilize oil prices. Under the "tit-for-tat" strategy, Saudi Arabia does not make an effort to stabilize oil prices; instead, to maintain its market share, Saudi Arabia matches cheating by other members.

[94] Obstfeld and Rogoff (2005, p.27-28) state that "During the years 1971-72 (in the run-up to the November 1972 election), the United States had relatively loose fiscal policy (fueled particularly by a generous election-year increase in social security benefits), soft monetary policy, and faced open ended security costs. Back then it was Vietnam; today it is Iraq and homeland security, the combined costs of which could easily match the cumulative 12% of GNP that the Vietnam War cost or the 15% of GNP that financed the Korean War... . There were twin deficits (albeit significantly smaller in the 1970s than they are today), and energy prices were a major factor (although the 1974 oil price hike was much greater, when measured in real terms, than anything seen yet in 2004.) The year 1973 saw a breakdown of the Bretton Woods fixed exchange rate system (mainly involving European countries), but today there is a quasi-fixed exchange rate system between the US and much of Asia."

[95] As explained by Enders (2004, p.282), the log likelihood ratio test recommended is $(N - k)$ (loglikelihood of the unrestricted model – loglikelihood of the restricted model), where N is the number of observations and k is the number of parameters in each equation. In this case, there are two unrestricted models and one restricted model. Also, there are 8 coefficients in each equation, because there are six variables, a constant and a trend. Hence, the log likelihood ratio test is equal to (164-8)*((1002.059+1563.922)-2432.852)=20768.124. The degrees of freedom are equal to the number of restrictions. In this case the degrees of freedom are equal to 48=(8*6).

6.2 Data for the Variables

To estimate the VAR model presented in equation (6), data are required for the US current account, US government debt, wealth, oil prices, global demand, and China's role in the world economy. As some data are available only on a quarterly basis, the frequency of the sample is restricted to be quarterly. A general description of the variables is provided here while complete data sources are provided in Appendix 3-1.

6.2.1 The US Current Account

The US current account data are normalized by GDP. The available US GDP data are seasonally adjusted. Therefore, the seasonally adjusted US current account data are used to compute the ratio of the US current account to GDP, which is illustrated in Figure 3-1.

6.2.2 US Fiscal Policy

The ratio of the federal debt held by the public to GDP is the measure used to capture the impact of US fiscal policy. The federal debt held by the public is federal debt held by individuals, corporations, state or local governments, foreign governments, and other US non-government entities, excluding Federal Financing Bank (FFB) securities. The ratio of the federal debt held by the public to GDP and the ratio of the US current account to GDP are illustrated in Figure 3-2.

6.2.3 US Household Wealth

The Standard and Poor's 500 (S&P500) index deflated by the US consumer price index (CPI) is used to represent wealth. These real stock prices and the US current-account-to-GDP ratio are illustrated in Figure 3-3.

The use of the S&P500 index as a proxy for wealth is motivated by Fratzscher and Straub (2010), Fratzscher et al. (2009), Fratzscher and Straub (2009), and Caballero et al. (2008b). Fratzscher and Straub (2010), Fratzscher et al. (2009), and Fratzscher and Straub (2009) utilize the S&P500 index as a US equity measure to study the impact of asset prices – a wealth effect – on the US current account.[96] Caballero et al. (2008b, p.43) employ the S&P500 index to examine the relationship between the spot crude oil price and stock prices, and to determine the "asset-role of oil". In the "Robustness" section, I employ an alternate US net wealth variable that I calculate using data from the B(100) Balance Sheet of Households and Non-profit Organizations of the Federal Reserve Board.

Another variable that can be used to proxy US wealth is the Standard and Poor's Case-Shiller 10-City Home Price Index. However, according to Sutton (2002), house prices are driven by shocks to national income and equity prices. This means that the home-price effect may be captured by other variables already included in the model. In addition, home prices may be driven by domestic political factors. For example, Ferrero (2012, p.5) gives an argument that the increase in the role of US government-sponsored enterprises (GSE) in providing easy credit was driven by a political response to the rise in income inequality and the interest in providing housing to low-income households.

6.2.4 Real Price of Oil

While there are several different oil prices, Figure 3-4 shows the three major crude oil prices – West Texas Intermediate (WTI), the United Arab Emirates price of oil (Dubai), and the British price of oil (Brent) – all move together.[97] The correlation between the daily data for these three oil prices is 0.99 over the period 29 January 1986 to 31 December 2010.[98] Given the similarities between these price series, the WTI price is chosen for this study. The monthly average real WTI oil price and the US current-account-to-GDP ratio are illustrated in Figure 3-5, where the monthly average spot oil price is deflated by the US CPI.

[96] Fratzscher and Straub (2010, p.3) state that "As to the role of the financial channel, wealth effects of an asset price shock should be more important in an economy in which the size of financial wealth is larger, in which financial markets are more liquid and in which fewer households are liquidity constrained. Indeed, empirically the sensitivity of the trade balance appears to be more important in countries in which the equity wealth of households is relatively large, as well as in countries that have a higher home bias in their equity holdings. This applies for instance to the United States, which not only has a deep equity market, but where also a relatively large share of equity wealth is held domestically".
[97] The link between WTI and Brent broke down in 2011, after the end of the sample used here.
[98] The starting date used to calculate the correlation between the oil price measures is based on data availability as pointed out in Appendix 3-1.

6.2.5 Kilian Index

An index generated by Kilian (2009b), referred to as the Kilian Index (KI), is used to represent global economic activity. Kilian (2009b) created this index from information on representative single voyage freight rates for bulk dry cargoes collected by Drewry Shipping Consultants Ltd. Examples of bulk dry cargoes are coal, iron ore, fertilizer and scrap metal.[99] Another monthly index on global real economic activity that can be used, as noted by Kilian (2009b), is the Organization for Economic Co-operation and Development (OECD) index of industrial production. Kilian (2009b), however, states that the advantage of the KI is that it captures the recent surge in demand for industrial commodities by emerging economies such as China and India. Figure 3-6 depicts KI.

6.2.6 China's Role in the World Economy

The ratio of China's imports and exports to the world's imports and exports is used as a measure of China's growing role in the world economy.[100] The seasonally adjusted China variable, which is used in the estimation, and the US current-account-to-GDP ratio are depicted in Figure 3-7.

Another variable that could potentially be used to capture the increased role of China in the world economy is the level of China's foreign exchange reserves. However, this variable is likely to be endogenous to the US current account. The reason is that China pegs its currency to the US dollar and restricts capital movements. The pegging of the Chinese currency to the US dollar, for instance, is modelled by Blanchard et al. (2005), as if the Chinese central bank "acquires all dollars flowing into China" such that "the wealth transfer from the US to the euro area and Japan is thus the US current account minus the fraction that is financed by the Chinese central bank" (Blanchard et al.,

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[99] The Kilian (2009b) index is measured at monthly frequency and goes back to January 1968. The steps undertaken by Kilian (2009b) to construct the index involve taking simple averages of the freight rates and eliminating the fixed effects for different routes, commodities and ship sizes. The latter step requires computing the period to period growth rates for each series as far as data are available, taking equal-weighted average of these growth rates, normalizing the value of the KI in January 1968 to unity, cumulating the average growth rates based on the normalization in January 1968, deflating the series with the US CPI and finally, detrending the real index.

[100] Graphically, this variable exhibits seasonality which is confirmed empirically. Hence, the variable is seasonally adjusted by regressing it on a constant and three seasonal dummy variables, and retrieving the sum of the residual and estimated intercept from this regression.

2005, p.37). This would cause China's reserves to be a function of the US current account.

7 Empirical Issues

7.1 Deterministic Trend and Stationarity

The VAR model presented by equation (6) "may be too restrictive to represent sufficiently the main characteristics of the data" (Richards, 2005, p.385). Hence, a deterministic linear trend may be essential to capture data movements. To account for deterministic terms, the reduced form VAR model presented in equation (6) becomes:

$$Y_t = A_0 + A_1 Y_{t-1} + \varphi D_t + e_t \qquad 6'$$

where D_t is a $(dx1)$ matrix that includes exogenous deterministic components, and φ is a parameter matrix.

From Table 3-1, the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test shows that all variables – except the wealth and China variables – are trend stationary. The Dickey-Fuller test shows that the wealth variable is stationary, and the Dickey-Fuller generalized least squares test shows that the first difference of the wealth variable is trend stationary. Given the China variable is a share of world trade, so it cannot be nonstationary in the long run, I employ all the variables in level form except for the wealth variable that is in first difference form, and I include a trend as an exogenous deterministic component in the VAR. Peersman and Robays (2009) include a trend in the VAR model they use to examine the response of the US and Euro Area economies to oil price changes.

Adding a trend to a VAR is one way to deal with non-stationarity. According to Enders (2004. p. 167), a trend stationary series can be rendered stationary by eliminating the deterministic trend, and a unit root series that is difference stationary can become stationary by differencing. The concern is applying an inappropriate method – to remove the trend – that would yield a non-invertible and non-stationary process in the moving average component of the VAR model, causing the model to be unstable. In the "Robustness" section, accordingly, the VAR model is re-estimated with a trend and all variables in level form, including the wealth variable, and without a trend and all variables – except KI – as detrended variables.[101]

7.2 Stability of the Model

The stability of the model is required for the model to converge to a stable equilibrium, and means that the VAR model is stationary with time invariant means, variances, and covariances. "If a VAR is stable, it is invertible and has an infinite-order vector moving-average representation. If the VAR is stable, impulse–response functions and forecast-error variance decompositions have known interpretations" (STATA Time Series Reference Manual, 2009. Stata: Release 11, p.439).

The benchmark model, in which all variables are in level form except for the wealth variable, which is first differenced, is found to be stable. In addition, the models used to check the robustness of the benchmark model are stable as well.

7.3 Lag Length Selection

The Schwartz Information Criterion (SIC) is applied to determine the number of lags to be included in the VAR model (Enders, 2004). Eight VAR(q) models are initially carried out, where $q = 1, \ldots, 8$. The SIC is then applied to decide on the appropriate number of lags. The SIC shows that a first-order 6x6 VAR model is appropriate. Hence, the results reported, hereafter, pertain to the first-order 6x6 VAR model that includes a trend.

8 Vector Autoregressive Analysis Methods

Three structural analysis summaries are used to analyze and understand the dynamic properties of the VAR model and the extent of the interaction between the variables. These structural analysis summaries are impulse response functions (IRF), forecast error variance decompositions (FEVD), and Granger causality tests. The IRF, FEVD, and Granger Causality tests are discussed in this section. The results from using IRF, FEVD, and Granger Causality tests are presented and discussed in the "Results" section.

[101] The Kilian Index (KI) is a detrended real index (Kilian, 2009b).

8.1 Impulse Response Functions

Impulse response functions (IRF) are of interest to examine the response of one variable, in a system of variables, to a unit impulse in another variable (Lutkephol, 2007, p. 51; Enders, 2004).

Repeated substitution of Y_{t-i} in equation (6) yields:

$$Y_t = \mu + e_t + \Psi_1 e_{t-1} + \Psi_2 e_{t-2} + \cdots. \qquad 11$$

Where the μ and Ψ_i parameters are functions of A_0 and A_1 in equation (6). But $e_t = \beta^{-1}\varepsilon_t$ and β is the lower triangular matrix described in Section 5. The impulse response function uses the estimates in equation (6) and the restrictions on β to identify the elements of β. Given $e_t = \beta^{-1}\varepsilon_t$, equation (11) can be rewritten as

$$Y_t = \mu + \delta_0\varepsilon_t + \delta_1\varepsilon_{t-1} + \delta_2\varepsilon_{t-2} + \cdots. \qquad 12$$

The orthogonalized impulse response function (OIRF) coefficients are represented by δ_{ij}. The impulse response coefficients are used to generate the time paths for the responses of the variable of interest. The $\delta_{ij}(0)$ parameter is the impact multiplier that captures the instantaneous impact of a one-unit change in ε_j on the variable y_i. Similarly, $\delta_{ij}(1)$ represents the impact after one-period of shock ε_j. Plotting the OIRF coefficients against the impulse horizon helps visualize the time path of the impact of each shock on the variable of concern (Enders, 2004). The maximum impulse horizon, H, used here is 32 quarters. The effect of the impulse shock will die away due to the stability of the model (Lutkephol, 2007, p. 53).

An issue with the impulse response functions is that they are based on estimated coefficients. Hence, it is necessary to construct confidence intervals (Enders, 2004). Kamps (2004) explains that, in a VAR model, estimates tend to be insignificantly different from zero at a 5% significance level, which is reflected in wide confidence intervals. Kamps (2004) states that accordingly, the literature on VAR models reports 68% confidence intervals. On the other hand, Enders (2004) states that at the 5% significance level, there is a chance that the actual values of the impulse response functions are within a two-standard deviation interval. Following Kilian (2008a and 2009b), I graphically report the one- and two-standard deviation intervals. In the "Results" section, I report the two-standard deviation interval unless otherwise specified. As well, I report the significance of the impulse response coefficients at 1%, 5%, and 10% significance levels in Appendices.

8.2 Forecast Error Variance Decomposition

According to Richards (2005), Enders (2004), and Stock and Watson (2001, p.106), the forecast error variance decomposition (FEVD) is used to study the extent to which the variance of the forecast error in predicting a variable is caused by a structural shock. Note that the FEVD is based on the structural shock $\boldsymbol{\varepsilon}_j$ and hence is sensitive to the causal ordering. Using the known VAR coefficients and $\boldsymbol{\varepsilon}_j$, the h-period ahead forecast error vector for a particular variable in Y_T is:

$$y_{i,T+h} - y_{i,T+h|T} = \sum_{s=0}^{h-1} \delta_{i1}^{s} \boldsymbol{\varepsilon}_{1,T+h-s} + \cdots + \sum_{s=0}^{h-1} \delta_{in}^{s} \boldsymbol{\varepsilon}_{n,T+h-s} \ . \qquad 13$$

Because the $\boldsymbol{\varepsilon}_j$ are orthogonal, i.e., $\sigma_{\varepsilon_j}^2 = var(\boldsymbol{\varepsilon}_{jt})$, the variance of the h-period forecast error is expressed as:

$$var(y_{i,T+h} - y_{i,T+h|T}) = \sigma_{\varepsilon_1}^2 \sum_{s=0}^{h-1} (\delta_{i1}^{s})^2 + \cdots + \sigma_{\varepsilon_n}^2 \sum_{s=0}^{h-1} (\delta_{in}^{s})^2 \ . \qquad 14$$

The part of $var(y_{i,T+h} - y_{i,T+h|T})$ caused by $\boldsymbol{\varepsilon}_j$ is:

$$FEVD_{i.j}(h) = \frac{\sigma_{\varepsilon_j}^2 \sum_{s=0}^{h-1} (\delta_{ij}^{s})^2}{\sigma_{\varepsilon_1}^2 \sum_{s=0}^{h-1} (\delta_{i1}^{s})^2 + \cdots + \sigma_{\varepsilon_n}^2 \sum_{s=0}^{h-1} (\delta_{in}^{s})^2}, i,j = 1, \ldots, n \ . \qquad 15$$

According to equation (15), the FEVD shows the fraction of movements in a variable due to its own shock versus shocks pertaining to other variables, reflecting the relative importance of different shocks (Enders, 2004, p.280). "Thereby, the forecast error variance is decomposed into the components accounted for by innovations in the different variables of the system. …This kind of analysis is sometimes called innovation accounting" (Lutkephol, 2007, p. 64).

If $\varepsilon_{y_{jt}}$ does not explain the FEVD of y_{it} at any forecast horizon, y_{it} is independent of $\varepsilon_{y_{jt}}$, and is considered exogenous. If $\varepsilon_{y_{jt}}$ does explain the FEVD of y_{it} at all forecast horizons, y_{it} is considered endogenous. Usually, a variable explains the lion's share of its own FEVD at short horizons, and explains smaller proportions at longer horizons. This is the case if other variables tend to affect this variable with a lag and have little contemporaneous effect (Enders, 2004).

8.3 Granger Causality

With the use of Granger causality, a VAR model can be utilized to study the forecasting ability of a variable or a set of variables for other variables. In a VAR model, a variable is said to not Granger cause another if the coefficients on the lagged values of the former are zero in the equation of the latter.

9 Results

This section discusses the reduced form VAR results and the associated structural analysis; i.e., Granger Causality, orthogonalized impulse response functions (OIRF), and forecast error variance decomposition (FEVD) analyses. The Schwartz Information Criterion (SIC) shows that a first-order 6x6 VAR model is most appropriate. While the results are robust to reversing the order of the KI and China variable, the results reported pertain to the first-order 6x6 VAR model in which the China variable is ordered first followed by KI.

9.1 Reduced-Form Vector Autoregressive Model

The results for the reduced-form 6x6 VAR model are presented in Table 3-3. Table 3-3 shows that in the US current-account-to-GDP ratio equation, the ratio of the US federal debt held by the public to GDP has a positive significant coefficient and the wealth variable has a negative significant coefficient. In addition, the table shows that the real price of oil has a positive insignificant coefficient, the China variable has a negative insignificant coefficient, and the KI has a positive insignificant coefficient. The real oil price has a significant impact on the US federal-debt-held-by-the-public-to-GDP ratio and on the wealth variable. KI and the China variable have significant effects on the US federal-debt-held-by-the-public-to-GDP ratio and on the real oil price. This suggests that US federal-debt-held-by-the-public-to-GDP ratio and the wealth variable affect the US current-account-to-GDP ratio directly, while the real oil price, KI, and the China variable affect the US current-account-to-GDP ratio indirectly. The table also shows that the variables in the US current-account-to-GDP ratio equation are jointly significant, and that the R^2 of this equation is 0.96 implying a good fit. Furthermore, the coefficients on the own lagged values in each equation are less than one, a requirement for the model to be stable.

9.2 Granger Causality

The results for Granger causality are presented in Table 3-4 and discussed in this sub-section. Table 3-4 shows that the ratio of the US current account to GDP is Granger caused by the ratio of the US federal debt held by the public to GDP and the wealth variable. As well, the current-account-to-GDP ratio is jointly Granger caused by all five variables. As expected, the results are consistent with the estimates in Table 3-3.

9.3 Impulse Response Functions

This sub-section discusses the orthogonalized impulse response function (OIRF) results and their consistency with the hypotheses on the determinants of the US current account. The results for the OIRF are presented in Figures 3-8 and 3-9, and in Table A3-1 (Appendix 3-2) and Table A3-2 (Appendix 3-3).

The focus is on the hypotheses with respect to the determinants of the current account. The other results are discussed to the extent that they have an indirect impact on the current account. In other words, the direct impact on the current account is discussed first and then this direct impact is explained with reference to the indirect effects. The indirect effects are only important to the extent that they can explain the direct impact.

9.3.1 Direct Impact on the US Current Account

In this sub-section, I look at the impact on the US current-account-to-GDP ratio of all the shocks. This would be the direct effect on the US current account. The results for the direct effect are presented in Figure 3-8, where the values depicted in Figure 3-8 are provided in Table A3-1 (Appendix 3-2).

Figure 3-8 shows the real price of oil has a significant positive effect on the ratio of the US current-account-to-GDP ratio. The values of the significant OIRF increase from 0.000326 in the first quarter to 0.001832 in the twelfth quarter, then decrease to 0.00179 in the sixteenth quarter. This finding is consistent with the results from Chapter Two, that an increase in oil price causes the US dollar to depreciate and accordingly the US trade balance and the current account to improve. Also, the positive impact of KI on the US current account in Figure 3-8 is consistent with the results in Kilian et al. (2007).

The wealth variable has a negative significant impact on the US current-account-to-GDP ratio. The values of the significant OIRF range from -0.001603 in the first quarter to -0.001019 in the eleventh quarter, reaching a maximum in the second quarter. The negative impact of the wealth variable on the US current account is consistent with an increase in US wealth causing consumption in the US to rise and the trade balance to deteriorate, worsening the US current account.

The impact of the federal-debt-held-by-the-public-to-GDP ratio on the US current-account-to-GDP ratio is positive and significant, and it reaches a maximum in the second quarter. The values of the significant OIRF are 0.000628 in the first quarter and 0.000649 in the second quarter. According to the "The Hypotheses Examined" section, this finding suggests that the twin deficits hypothesis does not hold for the US. The occurrence of "twin divergence" in the US is in line with Kim and Roubini (2008, p.364). They explain that during economic recessions, output falls, causing the fiscal balance to deteriorate and the current account to improve (Kim and Roubini, 2008, p.364). In addition, Cayen et al. (2010, p.10-11) state that "In overlapping generations models... agents with finite economic lifetimes discount future tax liabilities at a higher rate than the market real interest rate. As a result, consumers do not increase their saving to sufficiently account for the additional future tax burden. Instead, their investment in government debt crowds out investment in physical capital and foreign assets, and the reduction in savings leads to a fall in the long-run net foreign asset-to-GDP ratio.

Financing the increased level of foreign indebtness is facilitated through a depreciation of the currency, which boosts net exports."

9.3.2 Indirect Impact on the US Current Account

This sub-section looks at the effect of the shocks on the other variables. This would be the indirect effect on the US current account. This separation allows me to explain the direct effect by reference to the indirect effects. The indirect effects are only important to the extent that they work through a variable that has a significant direct effect. If a variable does not have a significant direct effect on the current account, no other variable can work indirectly through this variable. The results for the indirect effect are presented in Figure 3-9, where the values depicted in Figure 3-9 are provided in Table A3-2 (Appendix 3-3).

Oil price movements are explained by KI and the China variable. The increase in global economic activity – presented by KI – has a significant and positive impact on the oil price, where the values of the significant OIRF, at one-standard deviation confidence intervals, range from 0.016552 in the first quarter to 0.017185 in the tenth, reaching a maximum in the fourth quarter. This is consistent with Kilian's (2009a; 2009b) findings that the increase in oil prices is driven to a great extent by the increase in global economic activity. An increase in the China variable has a positive and significant impact on the real price of oil. The values of the significant OIRF range from 0.017631 in the first quarter to 0.034096 in the eighth quarter, where the OIRF reach a maximum in the fifth quarter. The positive impact means that the increase in China's trade causes oil prices to increase, which may result from the high oil intensity of Chinese production contributing to the increase in oil prices (Bénassy-Quéré et al., 2007).

The increase in the China variable has a positive and significant impact on the US federal-debt-held-by-the-public-to-GDP ratio. The values of the significant OIRF increase from 0.002202 in the first quarter to 0.017956 in the twenty-second quarter, where the OIRF values tend to level-off starting in the twenty-fourth quarter. The impact of the China variable on the wealth variable is positive; however, it is insignificant.

The real price of oil has a significant impact on the wealth variable. The impact is negative during shorter horizons, where the values of the significant OIRF decrease from -0.007149 in the first quarter to -0.000658 in the sixth quarter. At longer horizons, the impact is positive, where the values of the significant OIRF increase from 0.004396 in the fourteenth quarter to 0.005954 in the twenty-first quarter, after which the values of the OIRF start to level-off. The negative impact is consistent with Kilian and Park's (2009) findings that, when a precautionary-demand oil-price shock dominates the stimulus effect of a global-aggregate-demand oil-price shock, an oil-price increase has a negative effect on the US stock market. This result contradicts the "global savings glut" view that a higher oil price leads to higher world saving and an increase in demand for US assets, including US equities (Caballero et al., 2008a and 2008b).

The real price of oil has a significant and positive effect on the ratio of the US federal debt held by the public to GDP, where the OIRF reaches its maximum in the twenty-eighth quarter. The values of the significant OIRF increase from 0.000897 in the first quarter to 0.017966 in the twenty-third quarter. The increase in the oil price could lead to an increase in the ratio of the federal debt held by the public to GDP if a rise in the oil price reduces domestic output, as shown by Kilian (2009b), causing a fall in tax revenue.

The wealth variable has a negative and significant impact on the US federal debt held by the public to GDP, where the OIRF reaches its maximum in the tenth and eleventh quarters. The values of the significant OIRF increase from -0.002428 in the first quarter to -0.005609 in the eighth quarter. This negative effect is consistent with higher wealth and higher stock returns indicating increased personal incomes and corporate profits, so income tax revenues rise, causing debt to fall.

In summary, from Figure 3-8, both the debt variable and the wealth variable have significant effects on the current account as implied by the results in Table 3-3. However, Figure 3-8 also indicates that the real oil price has a positive effect on the current account. From Figure 3-9, this significant oil price effect comes through the effect of the oil price on the debt and wealth variables.

9.4 Forecast Error Variance Decomposition

In this sub-section, a 32-quarters FEVD is considered, as it is noted by Enders (2004) that it is useful to study the FEVD at different horizons and that variance decompositions tend to converge as the number of horizons increases. An overview of the FEVD is provided in sub-section 8.2. Figure 3-10 and Table 3-5 present the results for the FEVD of the US current-account-to-GDP ratio.

The FEVD results show that the proportion of movements in the US current-account-to-GDP ratio due to its own shock decreases from a value of 1 (implying that all first-quarter forecast error variance of the US current-account-to-GDP ratio is due to its own shock) to a value of 0.500999 in the ninth-quarter forecast error variance. On the other hand, the proportion of movements in the US current-account-to-GDP ratio due to all other shocks – i.e., shocks pertaining to the ratio of the federal debt held by the public to GDP, the wealth variable, real oil price, KI and the China variable – increases from a value of zero in the first-quarter forecast to a value of 0.499 in the ninth-quarter forecast. The real-oil-price and wealth-variable shocks explain a larger fraction than the other three shocks, where the wealth-variable shock dominates from the first- to the eleventh-quarter forecast error variance while the real-oil-price shock dominates afterwards.

In summary, the FEVD implies that the key determinants of movements in the US current account are movements in the wealth variable and movements in the real price of oil. Movements in the government debt variable, KI, and the China variable have the smallest contribution.

10 Robustness

10.1 All Variables in Levels

As discussed in Section 7.1, it is preferable to use the appropriate transformation of a variable. As a check of the first differencing of the wealth variable, in this sub-section, all variables in the VAR model are in levels, including the log of the S&P500

index-CPI-deflated (wealth variable). In addition, to discussing the OIRF pertaining to the direct effect on the US current-account-to-GDP ratio, the VAR estimates are used to simulate the US current-account-to-GDP ratio path and provide a counterfactual analysis.

10.1.1 Orthogonalized Impulse Response Functions

The OIRF – which are presented in Figure 3-11 – show that the results of the benchmark model are very similar to this variation of the model. The real price of oil still has a significant positive effect on the ratio of the US current-account-to-GDP ratio. The wealth variable still has a significant negative impact on the US current-account-to-GDP ratio. The impact of the federal-debt-held-by-the-public-to-GDP ratio on the US current-account-to-GDP ratio remains positive and significant, but for less time. Chinese trade growth still has a negative initial effect, but now the impact is significant for the first three quarters.

10.1.2 Counterfactual Analysis

The FEVD and Granger causality results show that the real oil price explains movements in the US current-account-to-GDP ratio. The OIRF results, for the benchmark model and for the case when all variables are in levels, show that the real oil price has a significant, positive and increasing effect on the US current-account-to-GDP ratio. On the other hand, Bernanke (2007) and Caballero et al. (2008b) state that oil exporters contributed to the increase in the US current account deficit during the 2000s.

To gain some sense of the magnitude of this effect, in this sub-section, the path of the US current-account-to-GDP ratio is dynamically simulated using the original real oil price and a hypothetical oil price. The hypothetical oil price follows the original series until 2007:4, after which the real oil price is assumed to be 10% lower than it actually was in 2008, 2009, and 2010.[102] The path simulated using the original data is used to check the robustness of the model.

[102] The hypothetical oil price in 2008, 2009 and 2010 is calculated using the following formula: {real oil price – [(0.1)(real oil price)]}. The hypothetical oil price used in the simulation is in log terms. A term generated by subtracting the hypothetical oil price (in log terms) from the original oil price series (in log terms) is added with a minus sign to the oil price equation in the reduced form VAR.

I carry out the two dynamic simulations in STATA, where the actual values are used as initial values after which solutions from previous periods are used to compute the lagged endogenous variables in each of the six equations of the reduced form VAR model. For the US current-account-to-GDP ratio, the actual values, simulated path, and simulated path using the hypothetical oil price series are presented in Figure 3-12. The figure shows that, if the real oil price had been 10% lower than it actually was in 2008, 2009, and 2010, the US current-account-to-GDP balance would have been lower. The difference between the two simulated paths shows that if the oil price had been 10% lower, the US current account deficit would have been around 0.1% higher in 2008, around 0.3% higher in 2009, and around 0.5% higher in 2010. This finding is consistent with the OIRF findings, but contradicts the conjectures of Bernanke (2007) and Caballero et al. (2008b).[103]

10.2 An Alternate Wealth Variable

To assess robustness, a US net wealth variable that is calculated using data from the B(100) Balance Sheet of Households and Non-profit Organizations provided by the Federal Reserve Board is employed in place of the S&P500 index variable in the benchmark model. This variable is calculated by subtracting total liabilities form total assets, and dividing by disposable income. This alternate wealth variable is presented along with the US current-account-to-GDP ratio in Figure 3-13, and along with the log of S&P 500 index deflated by CPI (the wealth variable in the benchmark model) in Figure 3-14. Unit root tests show that the variable is stationary; hence, it is included in level form. The OIRF results – which are presented in Figure 3-15 – show that, with the alternative wealth definition, the wealth effect is still negative, but smaller and significant for a shorter period. The impact of the other variables on the current account is similar to the benchmark case.

[103] The simulation results are robust when using a second-order VAR model.

10.3 Adding a Productivity Variable to the Benchmark Vector Autoregressive Model

As mentioned in the literature review, findings by Chakraborty and Dekle (2009) and Balakrishnan et al. (2009) do not support the hypothesis that US productivity growth is a determinant of the US current account deficit. Chakraborty and Dekle (2009) attribute the US current account deficit, in the 2000s, to financial liberalization and a decrease in the cost of international borrowing, rather than to an increase in productivity. However, a negative effect of an increase in productivity on the US current account would be consistent with the arguments of Frenkel and Razin (1996) and Bussiere et al. (2010). They find that a positive permanent-country-specific-productivity shock has a negative impact on the current account, because this shock causes investment to increase and savings to decrease. The reason is that a positive permanent-country-specific-productivity shock has a positive impact on current investment, on expectations regarding future investment, the capital stock and income; and accordingly on current consumption. In addition to the positive impact on domestic demand for US assets, the positive impact on expectations regarding future investment and income increases foreign demand for US assets, which may worsen the US net foreign position and the US current account.

To determine whether productivity may have contributed to the US current account deficit, a US-Euro Area (EA) productivity differential variable is added to the benchmark 6x6 VAR model. Two cases are considered. First, an increase in US productivity causes the return on capital in the US to increase, leading to an increase in foreign demand for US assets, including demand by emerging economies and oil exporting countries. Hence, the productivity variable is ordered last given the assumption that it is an exogenous shock that is driving all other factors. In the second case, I order the productivity variable after the real oil price to allow the US-EA productivity differential to be affected by the China variable, KI, and the real oil price.

As a measure of productivity, I use the ratio of real GDP to total employment. The choice of the productivity measure is driven by data availability and this measure is available on a quarterly basis for both the US and all European countries in aggregate. The ratio of the US productivity index to the European productivity index, and the US current-account-to-GDP ratio are both illustrated in Figure 3-16, while the US productivity index and the European productivity index are illustrated in Figure 3-17. For data sources for the productivity indexes, refer to Appendix 3-1.

The results for the orthogonalized impulse response functions (OIRF) for the 7x7 VAR models that include the productivity measure are presented in Figure 3-18. Figure 3-18 shows that the productivity variable has a negative and insignificant impact on the US current account in the two cases. As well, Figure 3-18 shows that the results from the benchmark 6x6 VAR model are robust to adding the productivity variable, because the significance and signs of the OIRF are unchanged, and their values are almost the same.

10.4 Detrending Variables in the Benchmark Vector Autoregressive Model

Instead of including a trend as an exogenous deterministic component in the all-variables-in-level 6x6 VAR model as in sub-section 10.1, in this sub-section all variables in the model, except KI, are detrended. The reason is that KI is a detrended variable (refer to sub-section 6.2.5). A detrended variable is formed from the residuals from an Ordinary Least Squares (OLS) regression that involves regressing that variable on a polynomial trend. Two cases are considered. In the first case, a first order trend is considered. In the second case, a quadratic trend is considered. The results, presented in Figure 3-19, do not differ greatly from the benchmark case.

11 Conclusion

In this chapter, I apply a VAR model to study the impact of China’s role in the world economy, global economic expansions, increases in oil prices, US wealth, and US government debt on the US current account. The VAR model allows for interaction between these variables. The variables included in the 6x6 VAR model are China’s exports and imports to the world’s exports and imports, an index of global economic activity, the real oil price, the CPI-deflated S&P500 index (to represent a wealth variable), the US-federal-debt-held-by-the-public-to-GDP ratio, and the US current-account-to-GDP ratio, respectively. I study the time sample 1986:1-2010:4, using quarterly data.

The orthogonalized impulse response functions (OIRF) show that the impact of oil price movements on the US current account is positive. This is consistent with an increase in the price of oil causing the US dollar to depreciate, as postulated by Chapters One and Two, resulting in higher exports and reduced imports. This finding is also consistent with Kilian et al. (2007) who find that positive precautionary-demand and global-aggregate-demand oil-price shocks improve the US non-trade balance, net foreign position and current account. The OIRF also show that the wealth variable has a negative impact on the US current account. This is attributed to higher wealth raising consumption and, thereby, the US demand for foreign goods which deteriorates the US trade balance. The US federal-debt-held-by-the-public-to-GDP ratio has a positive impact on the US current account, implying that the twin deficit hypothesis does not hold for the US.

The Granger causality and the reduced form VAR results show that the US current-account-to-GDP ratio is affected directly by the US federal-debt-held-by-the-public-to-GDP ratio and the wealth variable, and is affected indirectly by the real oil price and the China variable. In addition, the forecast error variance decomposition (FEVD), a measure of the relative importance of different shocks, shows that the proportion of movements in the US current-account-to-GDP ratio due to all other shocks is driven by the wealth-variable from the first- to the eleventh-quarter forecast error variance and then by the oil price variable.

The results are robust when using all variables in level form. In addition, when the path of the US current-account-to-GDP ratio is dynamically simulated using the original real oil price and a hypothetical oil price, it is found that if the real oil price had been 10% lower than it actually was in 2008, 2009, and 2010, the US current-account-to-GDP deficit would have been greater. This finding supports the OIRF results. The results are also robust when detrending the China variable, real oil price, wealth variable, the US-federal-debt-held-by-the-public-to-GDP ratio, and the US current-account-to-GDP ratio; when using an alternate wealth variable; and when adding a productivity variable to the model.

In short, Bernanke (2005a, 2005b, 2007) and Caballero et al. (2008b) attribute the increase in the US current account deficit in the first decade of the 2000s to the increase in the US government debt and the supply of global savings by emerging economies and oil exporters. This chapter finds that the increase in US government debt did not contribute to the widening of the US current account deficit. Further, in contrast to the "global savings glut" view of Bernanke (2005a, 2005b, 2007) and Caballero et al. (2008b), but in line with Kilian et al. (2007), this chapter finds that an oil-price increase has a positive impact on the US current account. However, this results from higher oil prices reducing equity prices and wealth, thereby reducing the demand for imports. Therefore, higher oil prices may not have a detrimental effect on the current account, but may have an unfavourable impact overall on the US economy.

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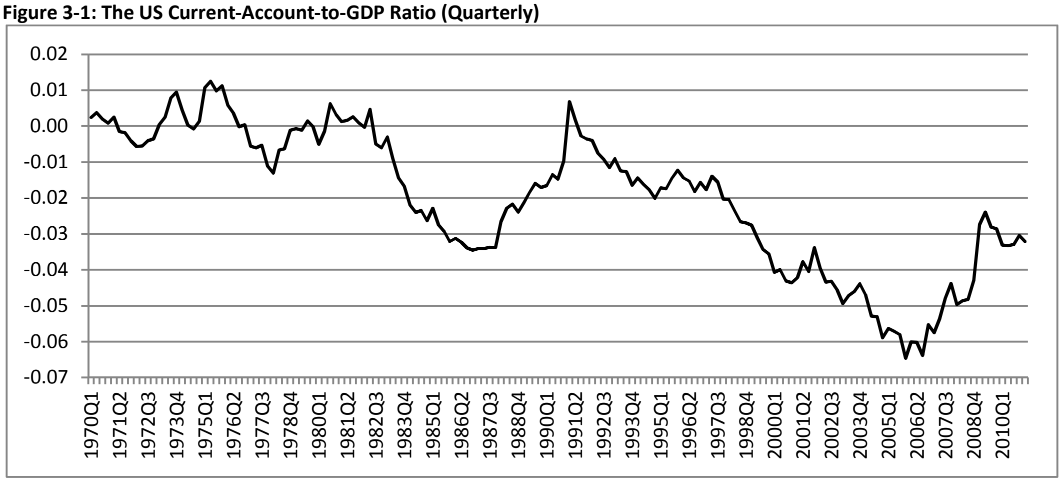
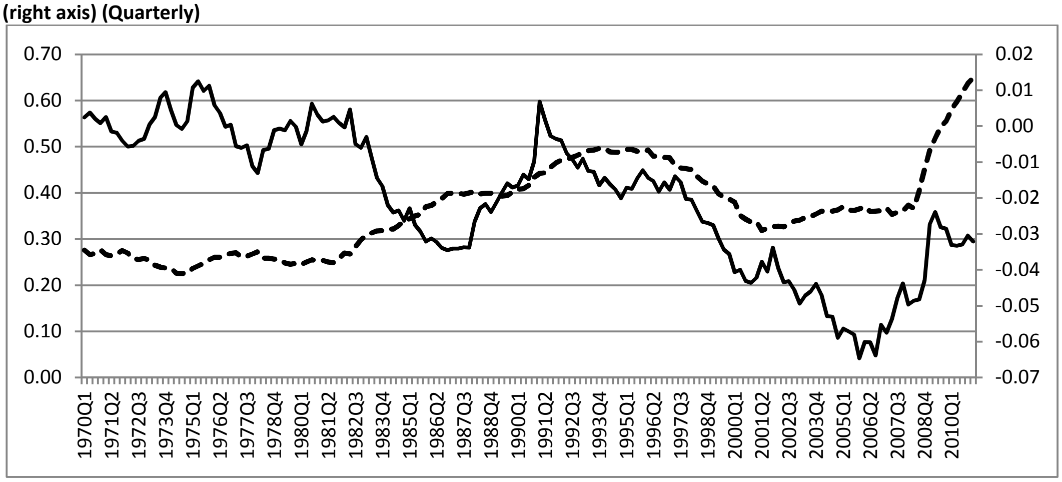
Figures

Figure 3-1: The US Current-Account-to-GDP Ratio (Quarterly)



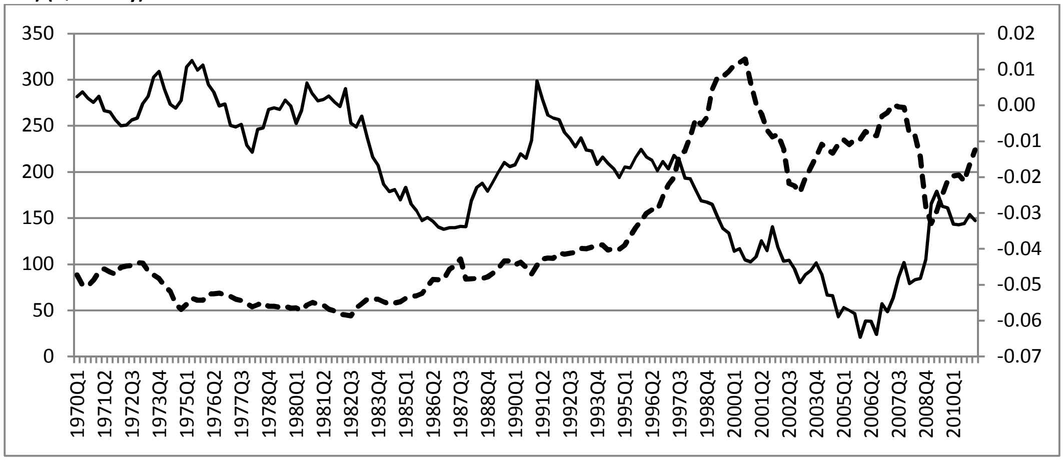
Source: Bureau of Economic Analysis

Figure 3-2: The US Federal-Debt-held-by-the-Public-to-GDP Ratio (left axis) and the US Current-Account-to-GDP Ratio (right axis) (Quarterly)



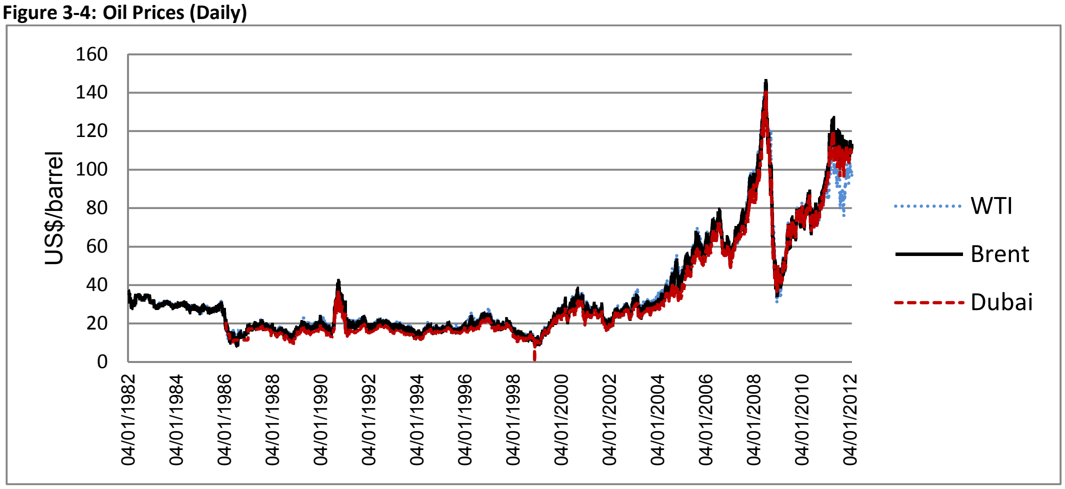
Source: Bureau of Economic Analysis and Federal Reserve Bank of St. Louis (FRED). The US current-account-to-GDP ratio is represented by the solid line.

Figure 3-3: The Standard and Poor's 500 Index CPI deflated (left axis) and the US Current-Account-to-GDP Ratio (right axis) (Quarterly)



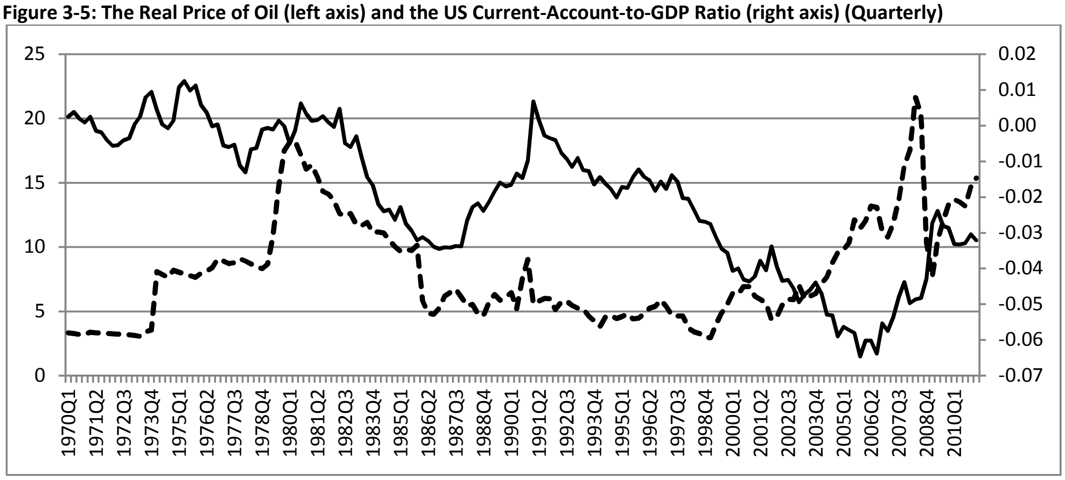
Source: Federal Reserve Bank of St. Louis (FRED) and *International Financial Statistics* (IFS). The ratio of the US current-account-to-GDP ratio is represented by the solid line.

Figure 3-4: Oil Prices (Daily)



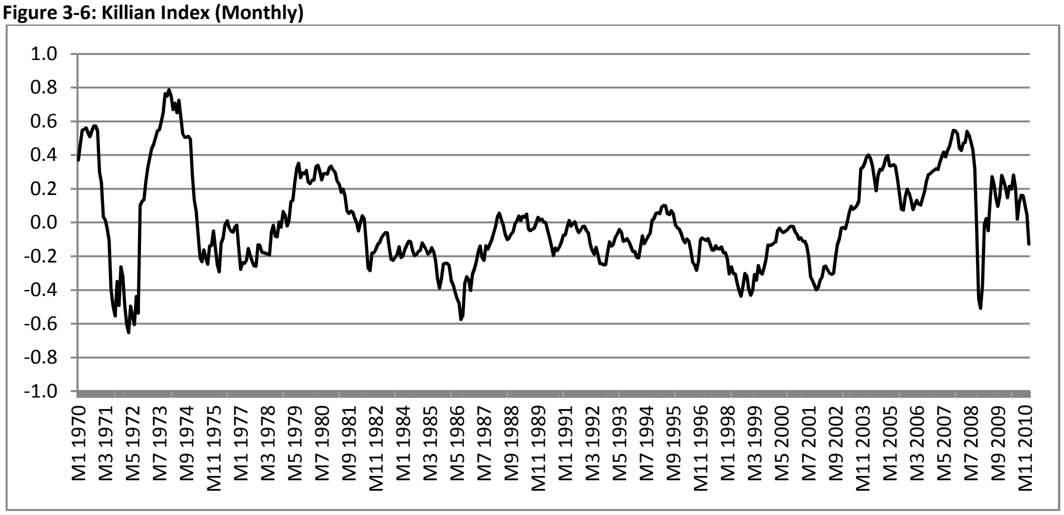
Source: DataStream

Figure 3-5: The Real Price of Oil (left axis) and the US Current-Account-to-GDP Ratio (right axis) (Quarterly)



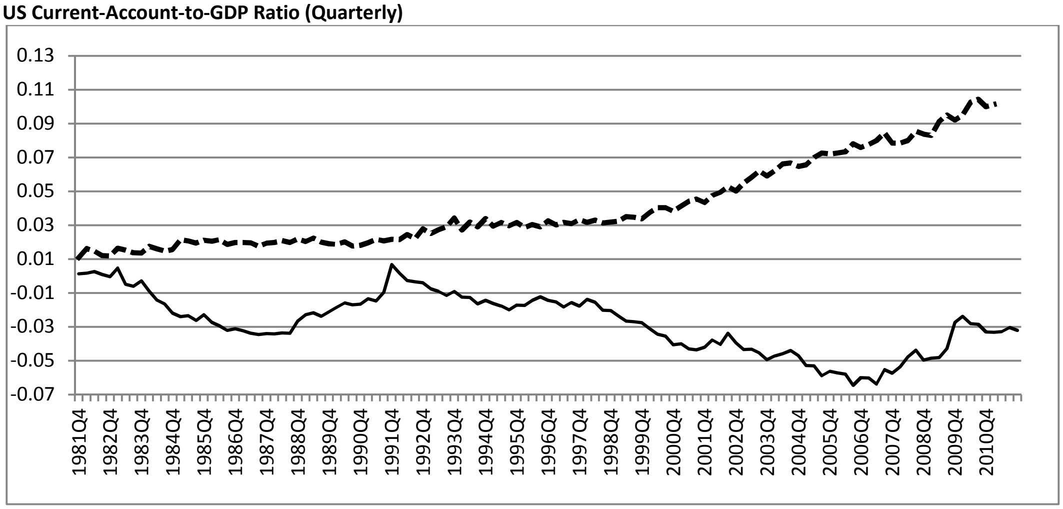
Source: Bureau of Economic Analysis and IFS. The ratio of the US current-account-to-GDP ratio is represented by the solid line.

Figure 3-6: Killian Index (Monthly)



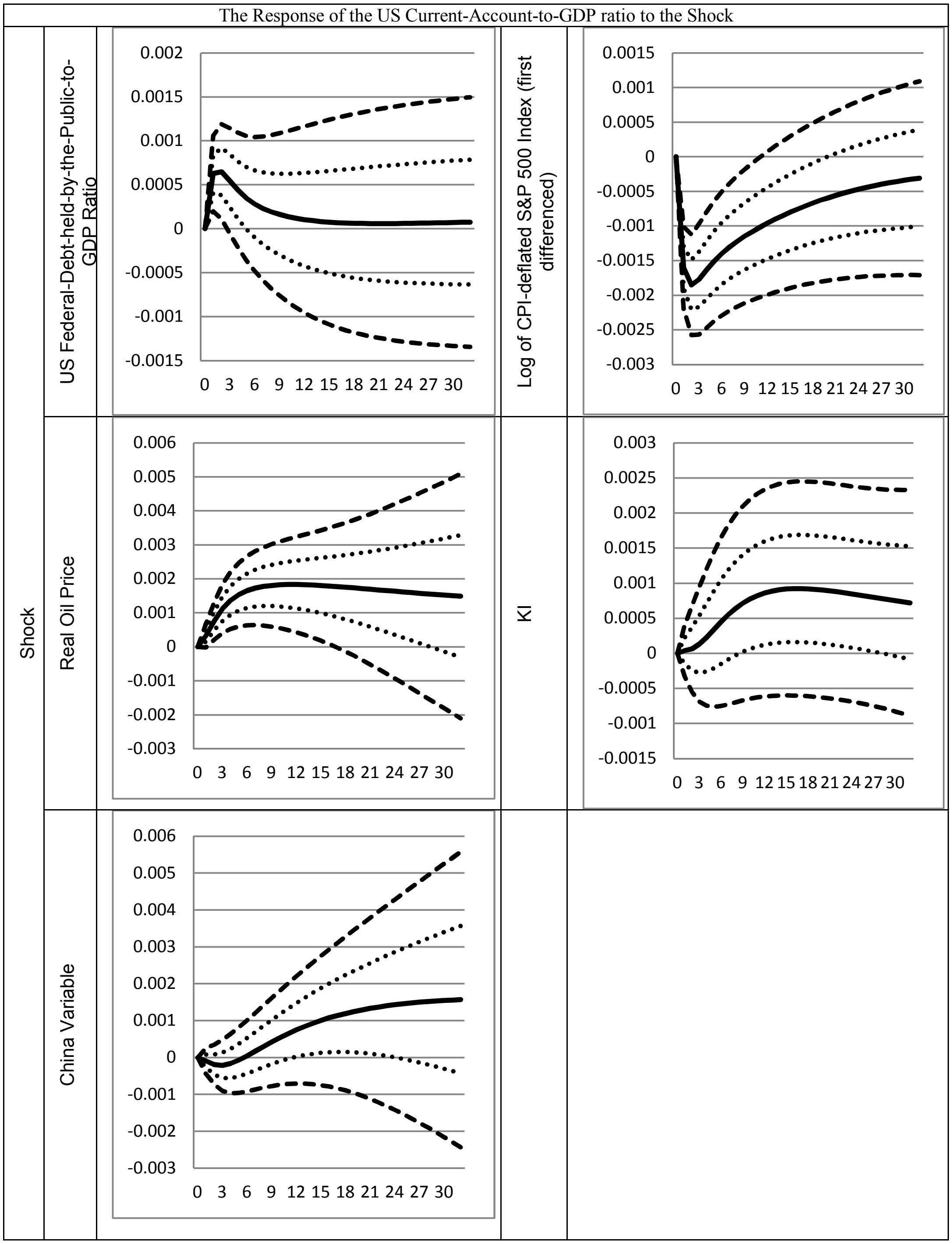
Source: Kilian (2009b) and URL: http://www-personal.umich.edu/~lkilian/reaupdate.txt

Figure 3-7: The Seasonally Adjusted Ratio of China's Imports and Exports to the World's Imports and Exports and the US Current-Account-to-GDP Ratio (Quarterly)



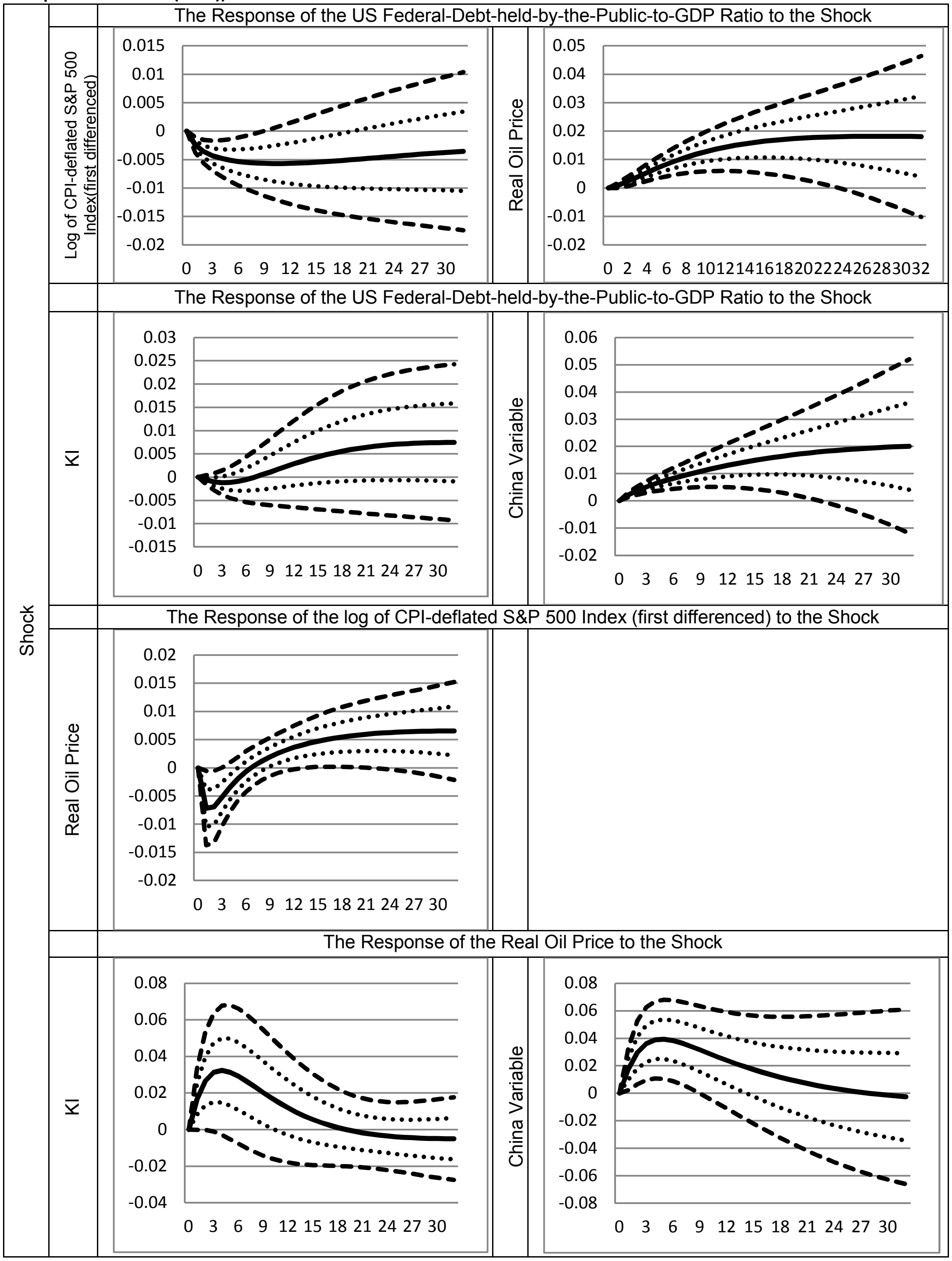
Source: Bureau of Economic Analysis and IFS. The ratio of the US current-account-to-GDP ratio is represented by the solid line.

Figure 3-8: Impact on the US Current-Account-to-GDP Ratio from the 6x6 VAR (Othogonalized Impulse Response Functions (OIRF))



Quarterly data are used for the period 1986:1 to 2010:4. The Y-axis represents the value of the othogonalized impulse response function (OIRF). The X-axis represents the horizon in quarters. The one- and two-standard deviation confidence intervals (CI) are calculated using the standard deviation of the othogonalized impulse response estimators. The values for the response estimators are represented in the graphs by the solid line. The one-standard deviation bounds are depicted by the dotted lines and the two-standard deviation bounds are represented by the dashed lines.

Figure 3-9: Indirect Impact on the US Current-Account-to-GDP Ratio from the 6x6 VAR (Othogonalized Impulse Response Functions (OIRF))



Quarterly data are used for the period 1986:1 to 2010:4. The Y-axis represents the value of the othogonalized impulse response function (OIRF). The X-axis represents the horizon in quarters. The one- and two-standard deviation confidence intervals (CI) are calculated using the standard deviation of the othogonalized impulse response estimators. The values for the response estimators are represented in the graphs by the solid line. The one-standard deviation bounds are depicted by the dotted lines and the two-standard deviation bounds are represented by the dashed lines.

Figure 3-10: Forecast Error Variance for the Current Account due to Own Shock and Other Shocks from the 6x6 VAR model

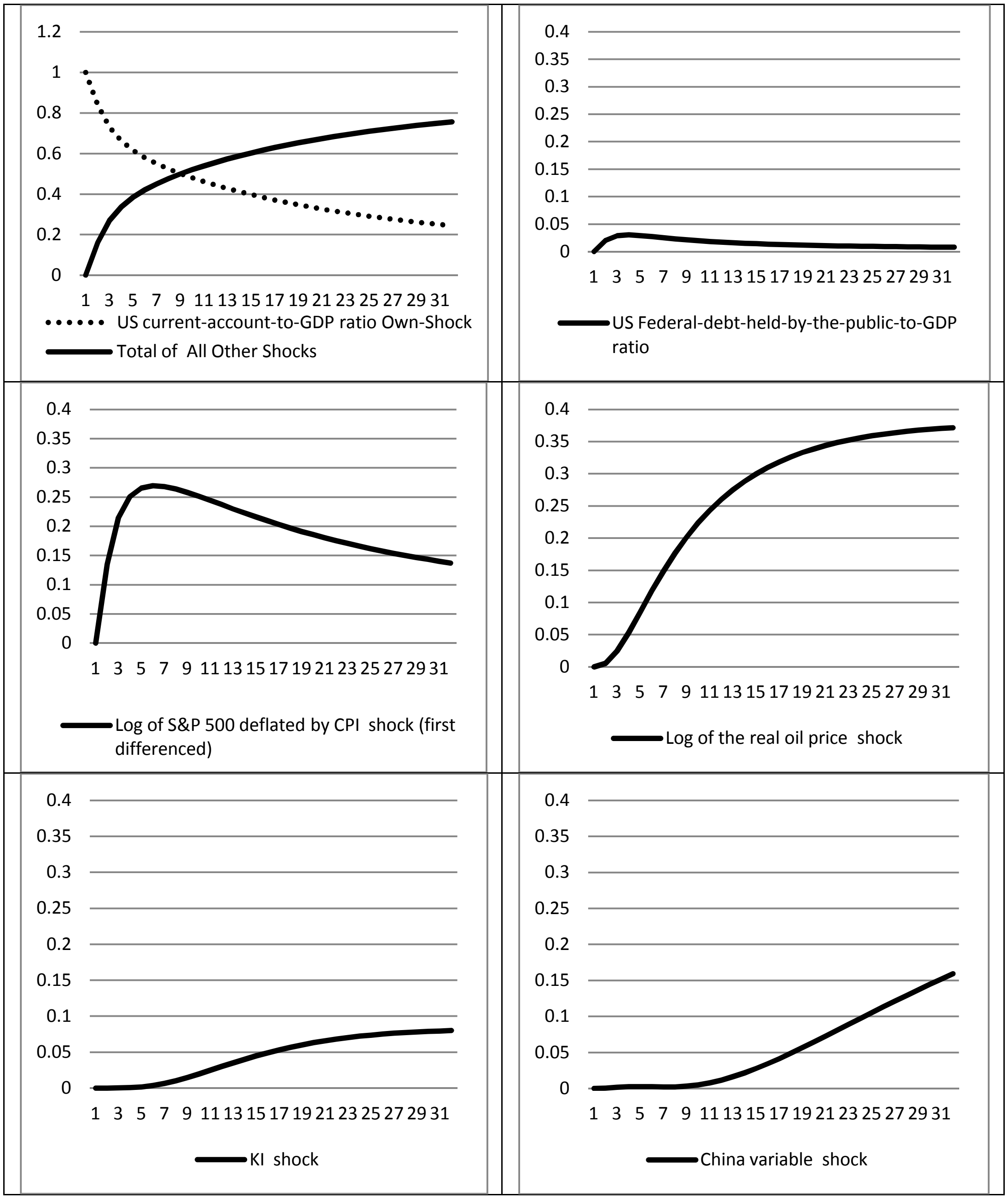
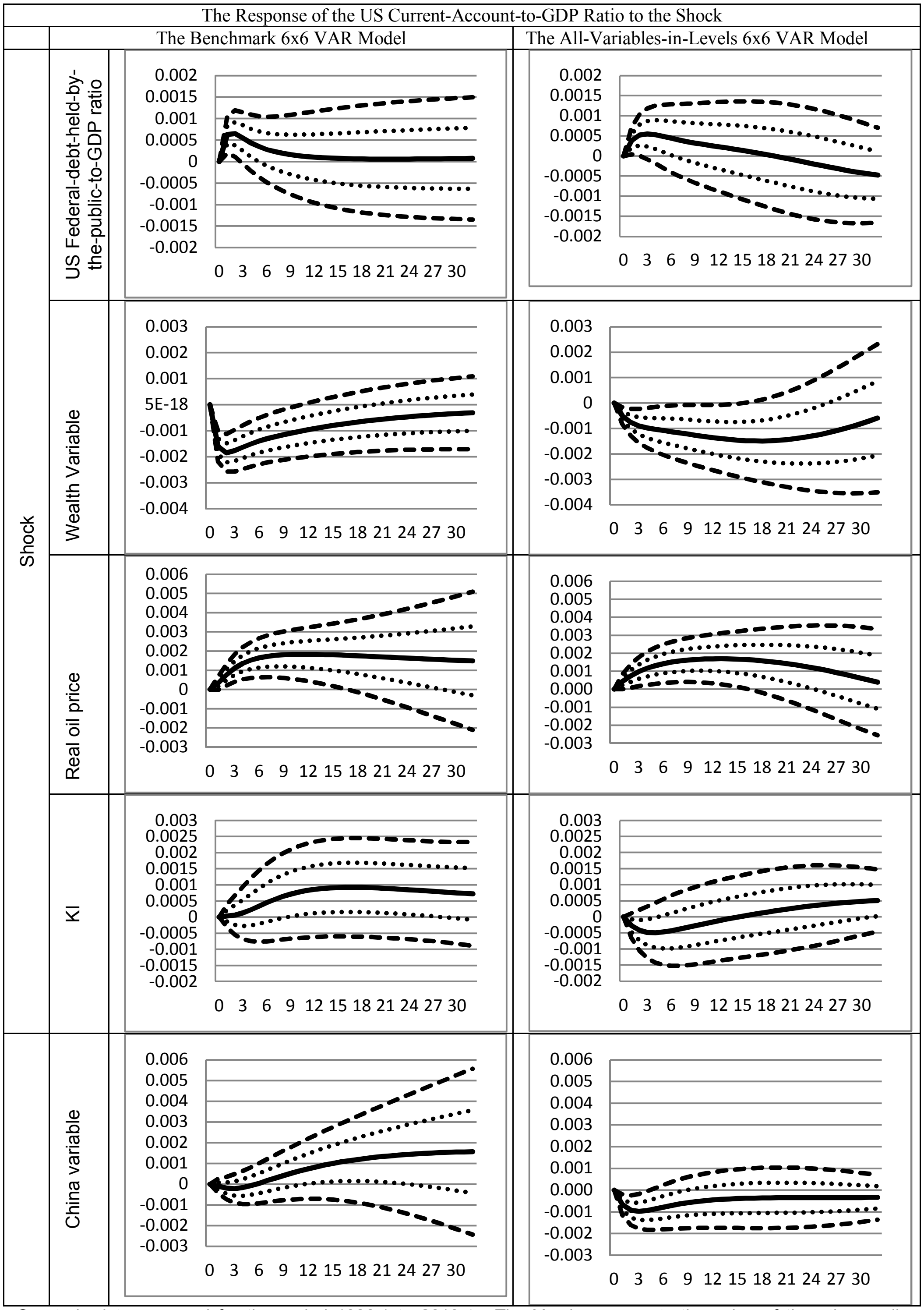
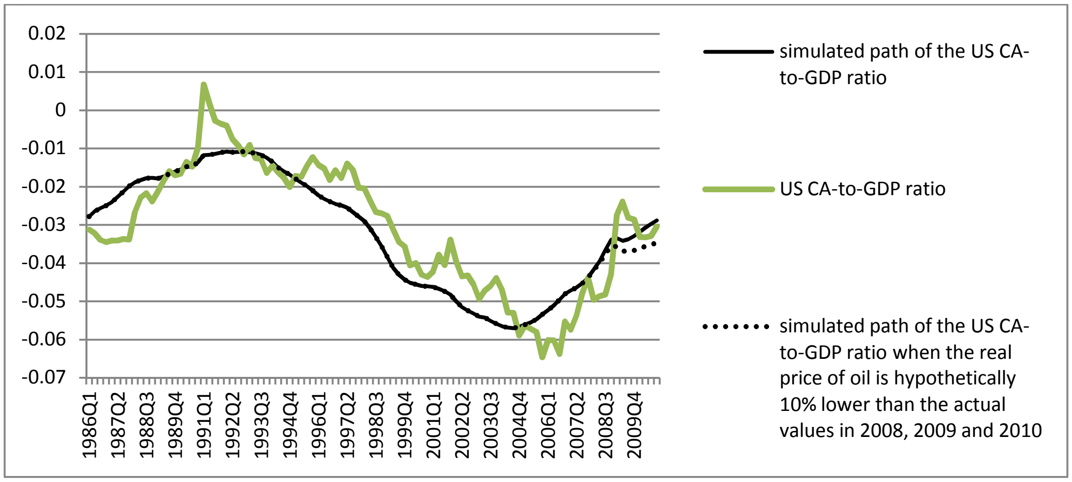


Figure 3-11: Impact on the US Current-Account-to-GDP Ratio from the Benchmark 6x6 VAR versus the All-Variables-in-Level 6x6 VAR Model (Othogonalized Impulse Response Functions (OIRF))



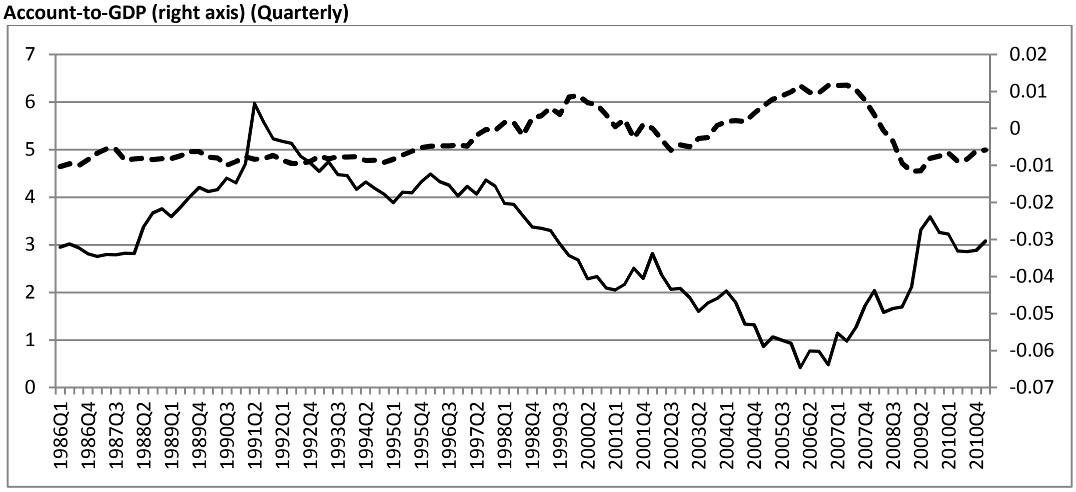
Quarterly data are used for the period 1986:1 to 2010:4. The Y-axis represents the value of the othogonalized impulse response function (OIRF). The X-axis represents the horizon in quarters. The one- and two-standard deviation confidence intervals (CI) are calculated using the standard deviation of the othogonalized impulse response estimators. The values for the response estimators are represented in the graphs by the solid line. The one-standard deviation bounds are depicted by the dotted lines and the two-standard deviation bounds are represented by the dashed lines.

Figure 3-12: Actual Values and Simulated Paths of the Ratio of the US Current Account (CA) to GDP



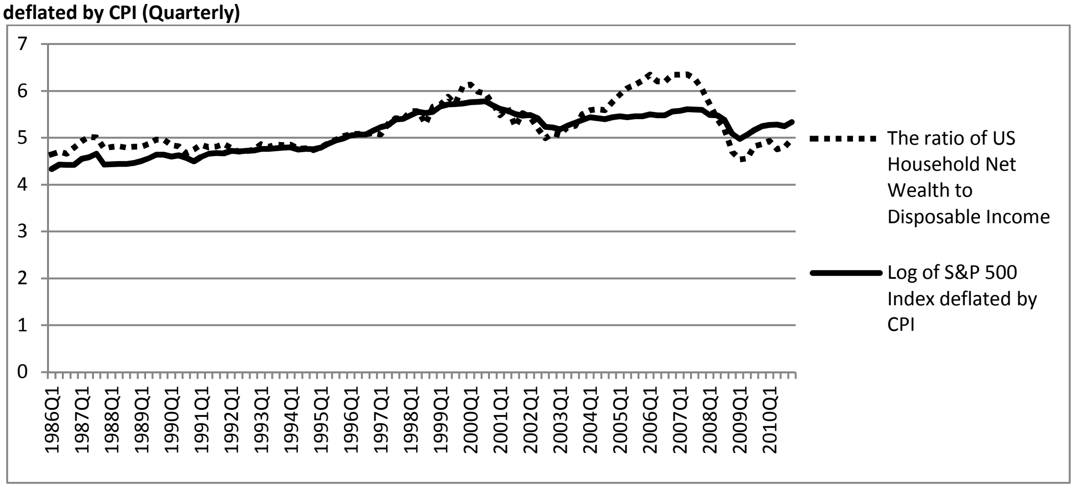
Source: Based on the 6x6 VAR model carried out by the author.

Figure 3-13: The Ratio of US Household Net Wealth to Disposable Income (left axis) and the Ratio of the US Current-Account-to-GDP (right axis) (Quarterly)



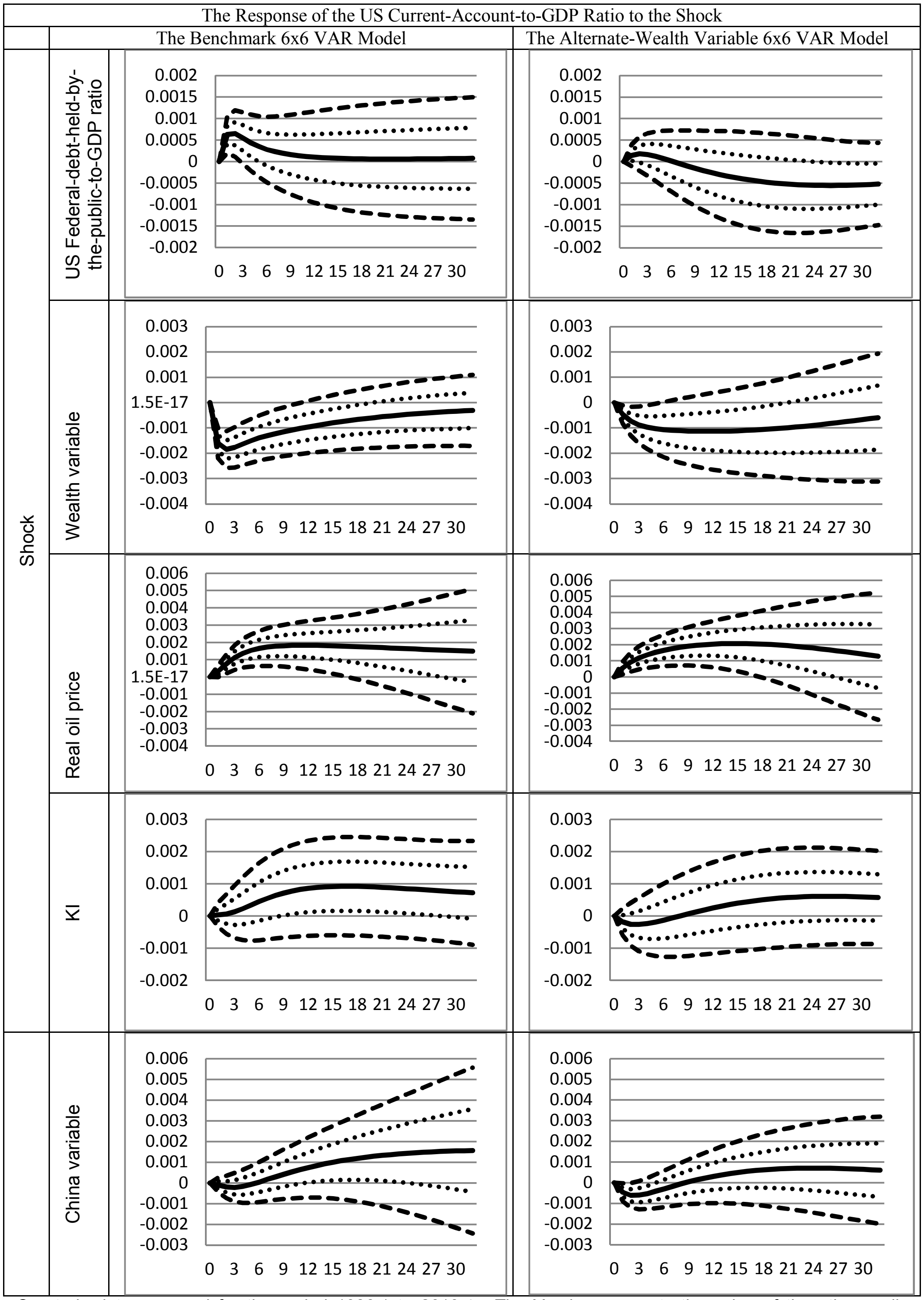
Source: Bureau of Economic Analysis and Federal Reserve Bank. The ratio of the US current-account-to-GDP ratio is represented by the solid line.

Figure 3-14: The Ratio of US Household Net Wealth to Disposable Income and the Log of Standard and Poor's 500 Index deflated by CPI (Quarterly)



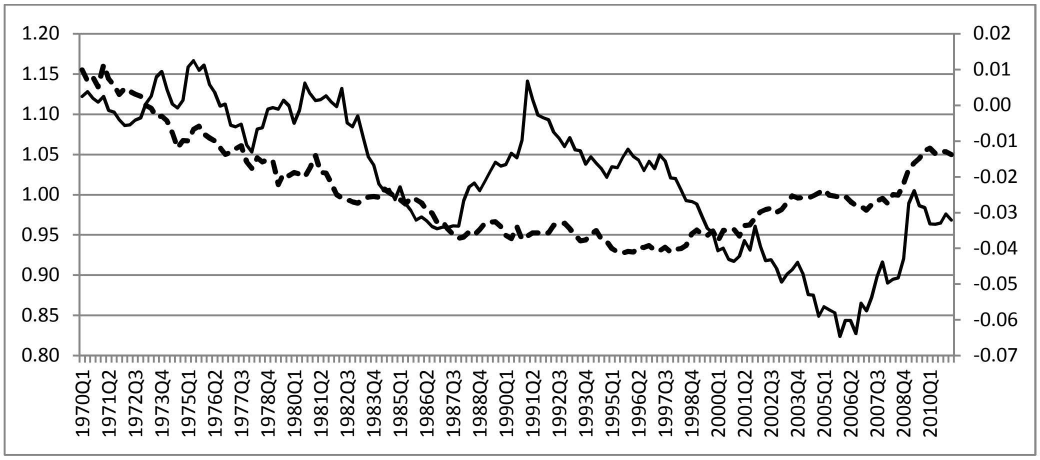
Source: Federal Reserve Bank, Federal Reserve Bank of St. Louis (FRED) and IFS.

Figure 3-15: Impact on the US Current-Account-to-GDP Ratio from the Benchmark 6x6 VAR versus the Alternate Wealth Variable 6x6 VAR Model (Othogonalized Impulse Response Functions (OIRF))



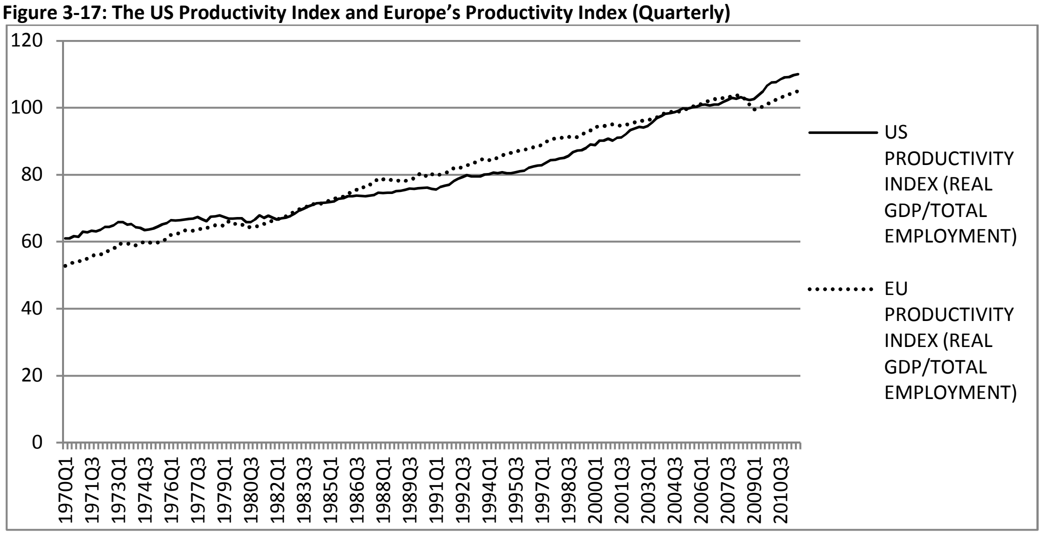
Quarterly data are used for the period 1986:1 to 2010:4. The Y-axis represents the value of the othogonalized impulse response function (OIRF). The X-axis represents the horizon in quarters. The one- and two-standard deviation confidence intervals (CI) are calculated using the standard deviation of the othogonalized impulse response estimators. The values for the response estimators are represented in the graphs by the solid line. The one-standard deviation bounds are depicted by the dotted lines and the two-standard deviation bounds are represented by the dashed lines.

Figure 3-16: US Productivity relative to European Productivity (left axis) and the US Current-Account-to-GDP Ratio (right axis) (Quarterly)



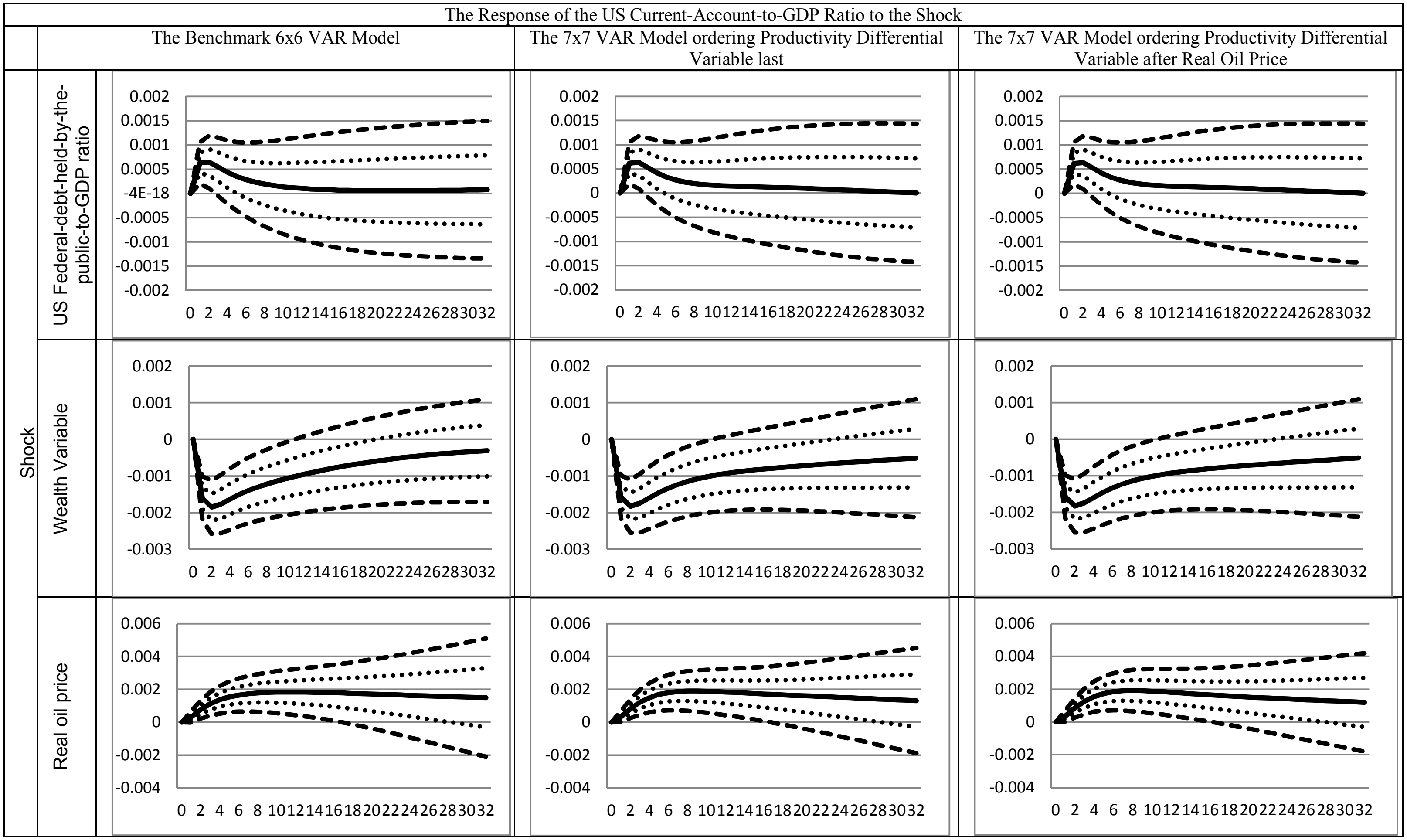
Source: Bureau of Economic Analysis and OECD Economic Outlook. The ratio of the US current-account-to-GDP ratio is represented by the solid line.

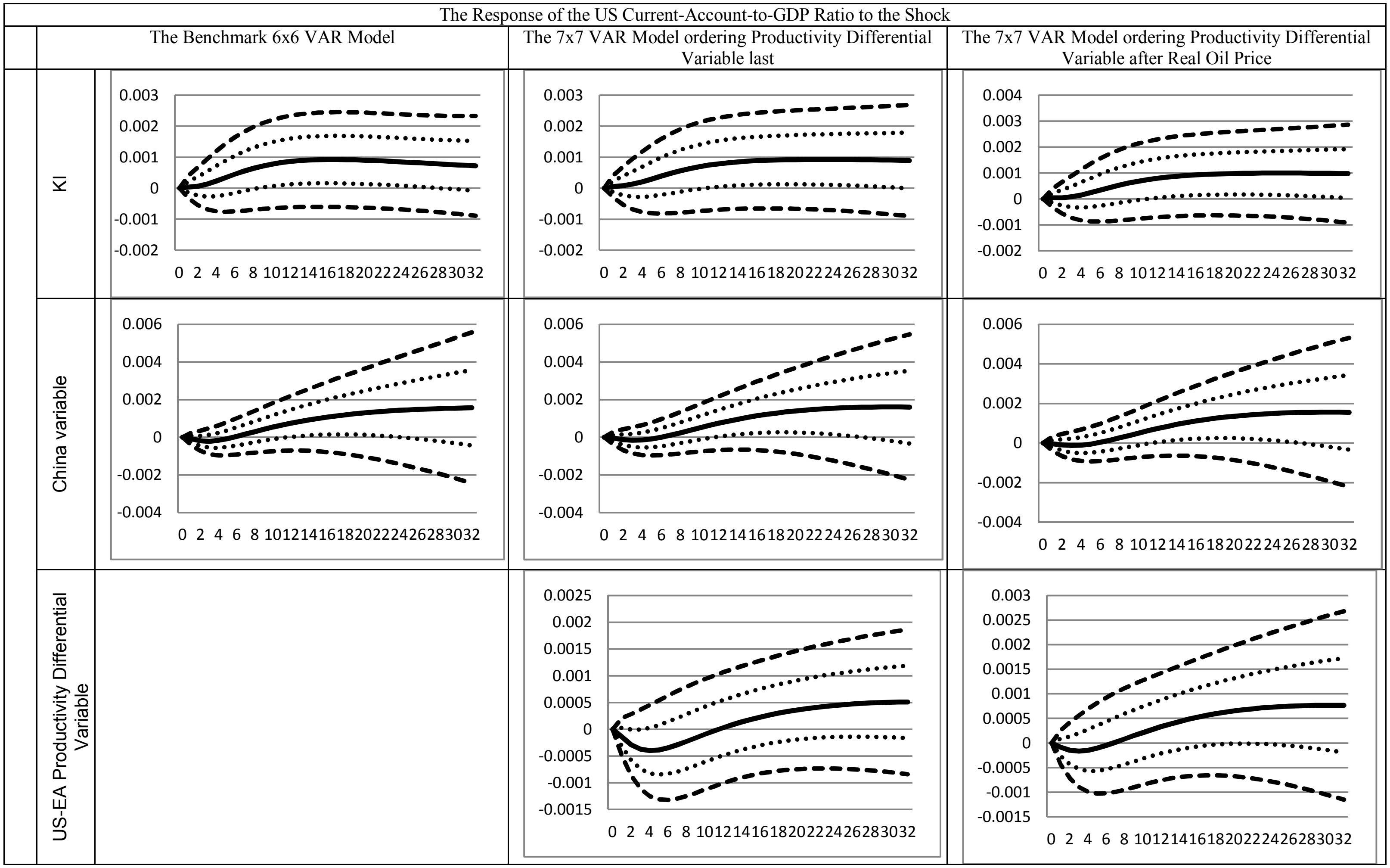
Figure 3-17: The US Productivity Index and Europe's Productivity Index (Quarterly)



Source: Bureau of Economic Analysis and OECD Economic Outlook

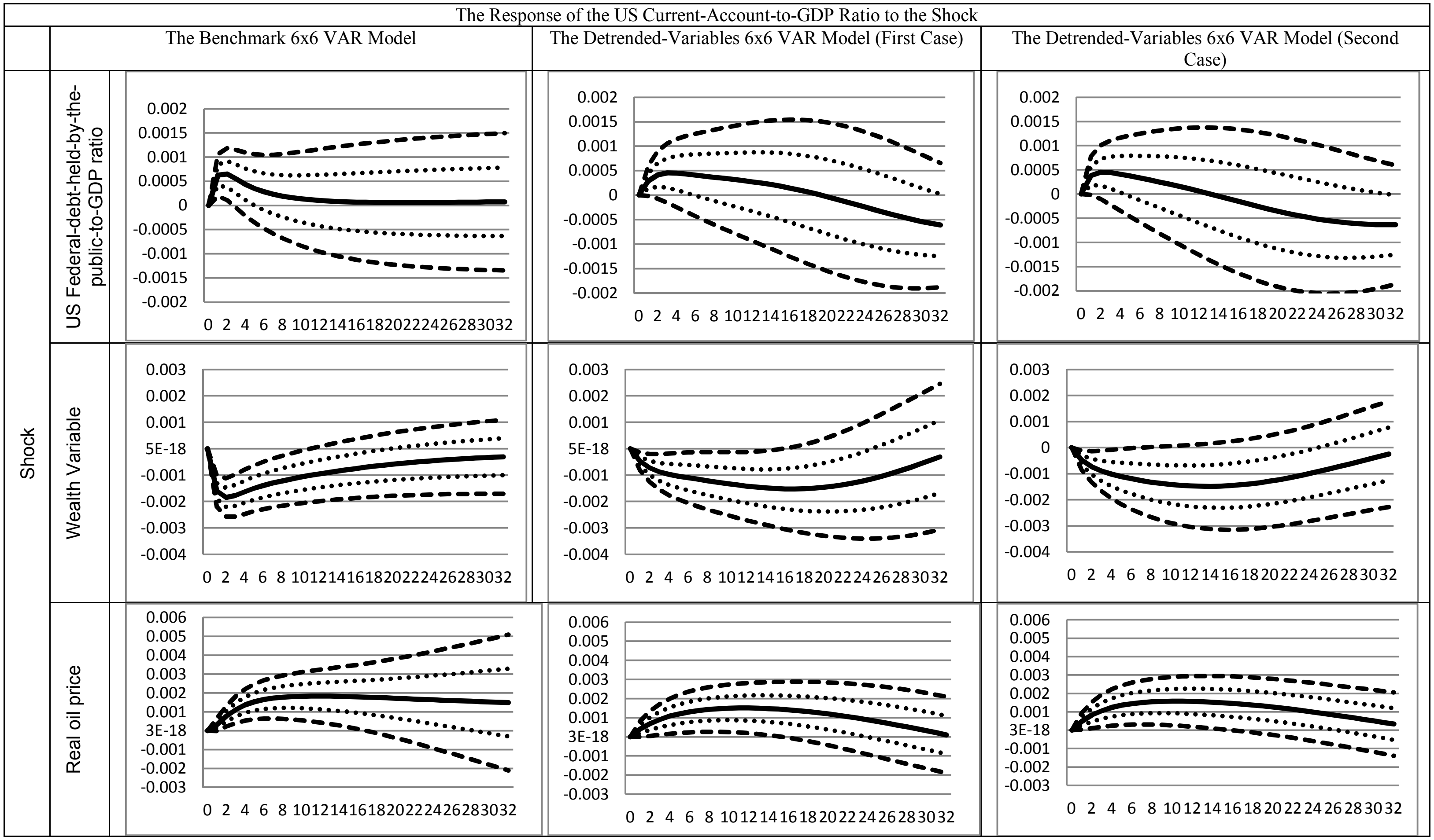
Figure 3-18: Impact on the US Current-Account-to-GDP Ratio from the Benchmark 6x6 VAR versus the 7x7 VAR Model with the US-EA Productivity Differential Variable (Othogonalized Impulse Response Functions (OIRF))

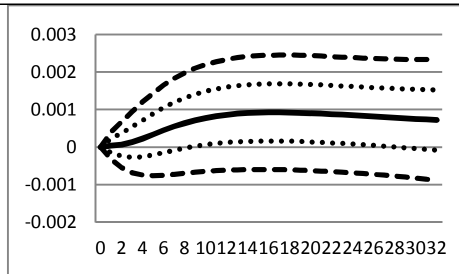
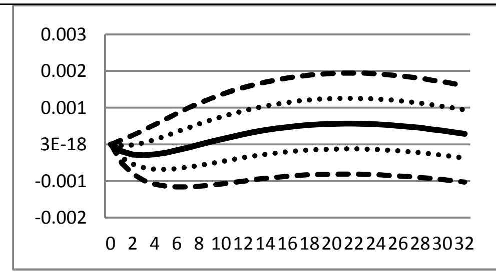
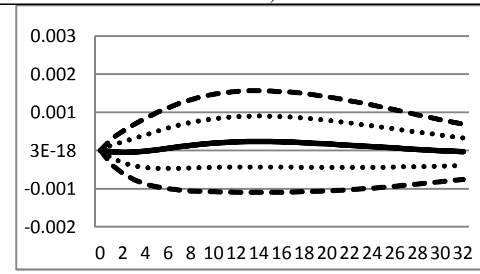
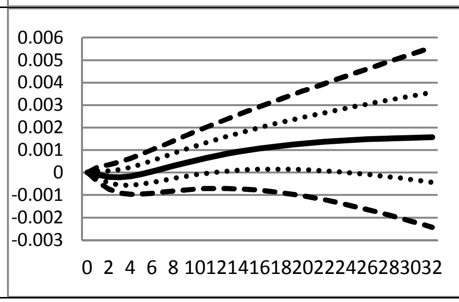
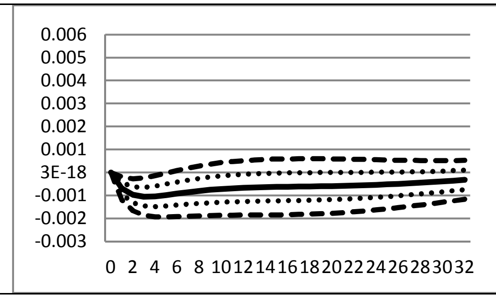
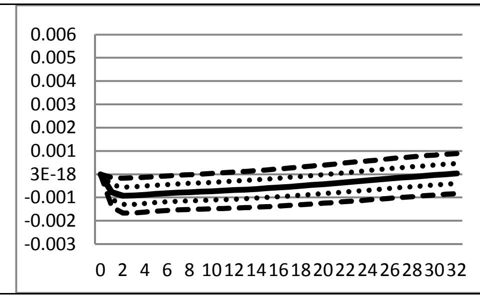




Quarterly data are used for the period 1986:1 to 2010:4. The Y-axis represents the value of the othogonalized impulse response function (OIRF). The X-axis represents the horizon in quarters. The one- and two-standard deviation confidence intervals (CI) are calculated using the standard deviation of the othogonalized impulse response estimators. The values for the response estimators are represented in the graphs by the solid line. The one-standard deviation bounds are depicted by the dotted lines and the two-standard deviation bounds are represented by the dashed lines.

Figure 3-19: Impact on the US Current-Account-to-GDP Ratio from the Benchmark 6x6 VAR versus the 6x6 VAR Model with Detrended Variables (Othogonalized Impulse Response Functions (OIRF))



<table>
<tr><td colspan="5">The Response of the US Current-Account-to-GDP Ratio to the Shock</td></tr>
<tr><td></td><td></td><td>The Benchmark 6x6 VAR Model</td><td>The Detrended-Variables 6x6 VAR Model (First Case)</td><td>The Detrended-Variables 6x6 VAR Model (Second Case)</td></tr>
<tr><td></td><td>KI</td><td>
</td><td>
</td><td>
</td></tr>
<tr><td></td><td>China variable</td><td>
</td><td>
</td><td>
</td></tr>
</table>

Quarterly data are used for the period 1986:1 to 2010:4. The Y-axis represents the value of the othogonalized impulse response function (OIRF). The X-axis represents the horizon in quarters. The one- and two-standard deviation confidence intervals (CI) are calculated using the standard deviation of the othogonalized impulse response estimators. The values for the response estimators are represented in the graphs by the solid line. The one-standard deviation bounds are depicted by the dotted lines and the two-standard deviation bounds are represented by the dashed lines.

Tables of Results

Table 3-1: Unit Root Tests

Test				US Current-Account-to-GDP Ratio	US Federal-Debt-held-by-the-Public-to-GDP Ratio	Log of CPI-Deflated S&P 500 Index	Log of CPI-Deflated S&P 500 Index *(First Difference)*	Log of the Real Oil Price	KI	China Variable
Dickey-Fuller (DF)[104]	Null hypothesis: Unit Root	Random walk without a drift (with a constant and without a time trend)	Z(t)	-1.177	2.215	-2.023	***-6.905****	-1.502	*-2.531*	1.29
		Random walk without a drift (without a constant and a time trend)	Z(t)	-0.597	2.687	1.47	***-6.794****	-0.096	***-2.564****	3.087
		Random walk with a drift (with a constant, and time trend is not in regression)	Z(t)	-1.177	2.215	***-2.023****	***-6.905****	***-1.502****	***-2.531****	1.29
		Random walk with or without a drift (unrestricted constant, and time trend is in regression)	Z(t)	-1.586	2.452	-1.147	***-6.987****	-3.082	-3.015	-1.696
DF-generalized least squares (GLS)	Null hypothesis: Unit Root	Test Statistic		-1.559	-2	-1.578		-1.611	-1.588	-0.479
		optimal lag		*6*	*12*	*1*	*0*	*2*	*9*	*4*
		Test Statistic		-1.259	-1.441	-1.578	***-5.015****	-1.611	***-3.319****	-0.479
		Minimum SIC		*1*	*5*	*1*	*1*	*2*	*1*	*4*
Phillips–Perron unit-root test	Null hypothesis: Unit Root	Random walk without a drift (with a constant and without a time trend)	Z(t)	-1.255	0.251	-1.96	***-6.877****	-1.605	***-2.635****	2.511
		Random walk without a drift (without a constant and a time trend)	Z(t)	-0.622	1.342	1.103	***-6.773****	-0.085	***-2.664****	5.093
		Random walk with or without a drift (unrestricted constant, and time trend is in regression)	Z(t)	-1.699	0.512	-1.541	***-6.951****	***-3.208****	***-3.234****	-1.281
Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test	Null hypothesis: Trend Stationary	With constant	LM-Statistic	***0.692385****	***0.147531****	0.899949	***0.224327****	***0.730057****	***0.619517****	1.120749
		With constant and a linear trend	LM-Statistic	***0.145249****	***0.144679****	0.217085	***0.055791****	0.261685	***0.141415****	0.299231

(*), (**) and (***) indicate a series is stationary at 10%, 5% and 1% significance levels. A variable the test indicates is stationary is in bold italics. Critical values are provided in Table 3-2.

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104 An augmented Dickey-Fuller test has the form: $\Delta y_t = \alpha + \beta y_t + \delta t + \gamma_1 \Delta y_{t-1} + \gamma_2 \Delta y_{t-2} + \cdots + \gamma_k \Delta y_{t-k} + \varepsilon_t$, where α is a constant and t is the time trend. The "Without a constant and a time trend" case is a random walk without a drift, where the equation is fit without α and t. The "With a constant and without a time trend" case has the same null hypothesis as the previous case except that α is included in the regression. The "With a constant, and time trend is not in regression" case refers to a random walk with a drift that does not include the time trend in the regression. In the case denoted as "Unrestricted constant, and time trend is in regression", y_t follows a random walk with or without a drift; i.e., α is unrestricted and t is included in the regression (STATA Time Series Reference Manual, 2009. Stata: Release 11, p.118).

Table 3-2: Critical Values for Unit Root Tests

Test		1% Critical Value	5% Critical Value	10% Critical Value
Dickey-Fuller	With a constant and without a time trend	-3.51	-2.89	-2.58
	Without a constant and a time trend	-2.6	-1.95	-1.61
	With a constant, and time trend is not in regression	-2.365	-1.661	-1.29
	Unrestricted constant, and time trend is in regression	-4.04	-3.45	-3.15
DF-GLS	Lags			
	12	-3.58	-2.745	-2.472
	11	-3.58	-2.776	-2.502
	10	-3.58	-2.808	-2.532
	9	-3.58	-2.839	-2.562
	8	-3.58	-2.869	-2.59
	7	-3.58	-2.898	-2.617
	6	-3.58	-2.926	-2.643
	5	-3.58	-2.952	-2.668
	4	-3.58	-2.977	-2.69
	3	-3.58	-3	-2.711
	2	-3.58	-3.021	-2.73
	1	-3.58	-3.039	-2.747
Phillips–Perron unit-root test	With a constant and without a time trend	-3.51	-2.89	-2.58
	Without a constant and a time trend	-2.6	-1.95	-1.61
	Unrestricted constant, and time trend is in regression	-4.04	-3.45	-3.15
KSSP test	With constant	0.739	0.463	0.347
	With constant and a linear trend	0.216	0.146	0.119

Table 3-3: The Benchmark 6x6 Reduced-Form VAR Results

Equation /lagged value of:	US Current-Account-to-GDP Ratio	US Federal-Debt-held-by-the-Public-to-GDP Ratio	Log of S&P 500 Deflated By CPI (first differenced)	Log of the Real Oil Price	KI	China Variable
US Current-Account-to-GDP Ratio	0.909815***	0.6227798***	-0.4767416	1.496945	-0.3720547	-0.018902
	18.32	***5.44***	*-0.51*	*0.69*	*-0.23*	*-0.45*
US Federal-Debt-held-by-the-Public-to-GDP Ratio	0.0197268**	0.9336733***	0.2356054	-0.5518536	-0.1251261	0.0048533
	2.00	***41.08***	*1.26*	*-1.28*	*-0.39*	*0.58*
Log of S&P 500 Deflated By CPI (first differenced)	-0.0293839***	-0.0388787***	0.2439625**	0.350223	-0.1371177	0.0032299
	-5.62	***-3.23***	***2.46***	*1.53*	*-0.8*	*0.72*
Log of the Real Oil Price	0.0024021	0.0086972**	-0.0634269*	0.6951316***	-0.1028505*	0.0019533
	1.41	***2.22***	***-1.97***	***9.33***	***-1.84***	*1.35*
KI	0.0006688	-0.0114856**	0.0081296	0.1688731*	0.869448***	-0.0008469
	0.3	***-2.22***	*0.19*	***1.72***	***11.76***	*-0.44*
China variable	-0.0359847	0.8533782***	1.549698	6.83301**	3.706045*	0.8844427***
	-0.54	***5.52***	*1.22*	***2.33***	***1.68***	***15.47***
Trend	-0.0000407	-0.0003993***	-0.0011115	-0.0020605	-0.0016773	0.0000925***
	-1.02	***-4.35***	*-1.47*	*-1.18*	*-1.28*	***2.72***
Constant	-0.0089505	0.0414054**	0.0750405	0.7942396**	0.2658389	-0.0110947*
	-1.23	***2.46***	*0.54*	***2.49***	*1.11*	***-1.78***
Number of Parameters	8	8	8	8	8	8
Root Mean Square Error (RMSE)	0.003294	0.007588	0.062329	0.144071	0.108257	0.002806
R-sq	0.9633	0.9888	0.211	0.8966	0.7953	0.9884
chi2	2627.295	8847.056	26.74054	867.3168	388.5001	8504.236
Number of Observations	100	100	100	100	100	100

Data are quarterly.

The values of the estimates are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.

(*), (**) and (***) indicate the 10%, 5% and 1% significance levels of the variables.

Table 3-4: Granger Causality Tests for the Benchmark 6x6 VAR model

Equation	Excluded	chi2	Degrees of freedom	α (significance level) 1%	5%	10%
US current-account-to-GDP ratio	US Federal-debt-held-by-the-public-to-GDP ratio	3.999	1		√	
	Log of CPI-deflated S&P 500 index (First differenced)	31.548	1	√		
	Log of the real oil price	1.9869	1			
	KI	0.08839	1			
	China variable	0.28734	1			
	ALL	47.66	5	√		
US Federal-debt-held-by-the-public-to-GDP ratio	US current-account-to-GDP ratio	29.613	1	√		
	Log of CPI-deflated S&P 500 index (First differenced)	10.406	1	√		
	Log of the real oil price	4.9075	1		√	
	KI	4.9121	1		√	
	China variable	30.446	1	√		
	All	110.53	5	√		
Log of CPI-deflated S&P 500 index (First differenced)	US current-account-to-GDP ratio	0.2572	1			
	US Federal-debt-held-by-the-public-to-GDP ratio	1.5929	1			
	Log of the real oil price	3.8684	1		√	
	KI	0.03647	1			
	China variable	1.4881	1			
	All	11.07	5		√	
Log of the real oil price	US current-account-to-GDP ratio	0.47462	1			
	US Federal-debt-held-by-the-public-to-GDP ratio	1.6357	1			
	Log of CPI-deflated S&P 500 index (First differenced)	2.3423	1			
	KI	2.9458	1			√
	China variable	5.4148	1		√	
	All	14.628	5		√	
KI	US current-account-to-GDP ratio	0.05193	1			
	US Federal-debt-held-by-the-public-to-GDP ratio	0.14893	1			
	Log of CPI-deflated S&P 500 index (First differenced)	0.6359	1			
	Log of the real oil price	3.3718	1			√
	China variable	2.8211	1			√
	All	5.2145	5			
China variable	US current-account-to-GDP ratio	0.19956	1			
	US Federal-debt-held-by-the-public-to-GDP ratio	0.33362	1			
	Log of CPI-deflated S&P 500 index (First differenced)	0.52535	1			
	Log of the real oil price	1.8109	1			
	KI	0.19539	1			
	All	2.1713	5			

Table 3-5: Forecast Error Variance Decomposition of the US Current-Account-to-GDP Ratio from the Benchmark 6x6 VAR Model

	Own-Shock	Other Shocks					
Quarter	US current-account – to-GDP ratio Own-shock	US federal-debt-held-by-the-public-to-GDP ratio shock	Log of S&P 500 deflated by CPI (first differenced) shock	Log of the real oil price shock	KI shock	China variable shock	Total of all other shocks
1	1	0	0	0	0	0	0
2	0.838169	0.020693	0.135012	0.005591	0.000081	0.000453	0.16183
3	0.729853	0.029158	0.214457	0.02471	0.000198	0.001625	0.270148
4	0.662312	0.030552	0.250831	0.053213	0.000614	0.002479	0.337689
5	0.615242	0.029315	0.26555	0.085594	0.001672	0.002628	0.384759
6	0.579084	0.027288	0.269563	0.118108	0.003624	0.002333	0.420916
7	0.549352	0.02516	0.268119	0.148759	0.006539	0.002071	0.450648
8	0.523748	0.02317	0.263803	0.176684	0.010322	0.002273	0.476252
9	0.500999	0.021386	0.257949	0.20165	0.014784	0.003231	0.499
10	0.480358	0.019813	0.251287	0.223737	0.019704	0.005102	0.519643
11	0.461366	0.018432	0.244236	0.243166	0.024867	0.007932	0.538633
12	0.443731	0.017221	0.237052	0.260208	0.030091	0.011697	0.556269
13	0.427258	0.016156	0.229895	0.275137	0.035229	0.016325	0.572742
14	0.411813	0.015216	0.222866	0.288208	0.040175	0.021722	0.588187
15	0.397294	0.014384	0.21603	0.299655	0.044852	0.027783	0.602704
16	0.383626	0.013645	0.209428	0.309682	0.049215	0.034405	0.616375
17	0.370743	0.012984	0.203083	0.318468	0.053236	0.041487	0.629258
18	0.358593	0.012391	0.197007	0.326167	0.056907	0.048935	0.641407
19	0.347127	0.011857	0.191205	0.332915	0.06023	0.056666	0.652873
20	0.336301	0.011375	0.185675	0.338829	0.063216	0.064604	0.663699
21	0.326076	0.010937	0.180413	0.34401	0.06588	0.072684	0.673924
22	0.316414	0.010538	0.175409	0.348546	0.068243	0.080849	0.683585
23	0.307281	0.010175	0.170655	0.352516	0.070326	0.089048	0.69272
24	0.298644	0.009842	0.166139	0.355986	0.072151	0.097239	0.701357
25	0.290471	0.009536	0.161851	0.359016	0.07374	0.105386	0.709529
26	0.282734	0.009255	0.157778	0.361658	0.075116	0.11346	0.717267
27	0.275405	0.008995	0.153909	0.363957	0.076298	0.121435	0.724594
28	0.268459	0.008755	0.150233	0.365955	0.077307	0.129291	0.731541
29	0.261871	0.008533	0.146739	0.367687	0.07816	0.13701	0.738129
30	0.255619	0.008328	0.143416	0.369184	0.078874	0.14458	0.744382
31	0.249681	0.008136	0.140254	0.370474	0.079464	0.15199	0.750318
32	0.244037	0.007959	0.137244	0.371583	0.079945	0.159233	0.755964

Appendices

Appendix 3-1: Data Sources

Variable	Source	Remarks
US Current Account	Table 1. U.S. International Transactions, U.S. International Transactions Accounts Data, US Department of Commerce, Bureau of Economic Analysis. URL: http://www.bea.gov/international/bp_web/simple.cfm?anon=71&table_id=1&area_id=3	Millions of Dollars Seasonally adjusted and non-seasonally adjusted data are available. The seasonally data are used. (Data are on quarterly basis which is the lowest frequency available)
US GDP	Table 1.1.5. Gross Domestic Product, National Income and Product Accounts Table, US Department of Commerce, Bureau of Economic Analysis. URL: http://www.bea.gov/national/nipaweb/TableView.asp?SelectedTable=5&Freq=Qtr&FirstYear=2008&LastYear=2010	Billions of dollars Seasonally adjusted at annual rates (Data are on quarterly basis which is the lowest frequency available)
US Federal Debt held by the public	Federal Reserve Bank of St. Louis (FRED), URL: http://research.stlouisfed.org/fred2/series/FYGFDPUN/	Millions of Dollars Monthly data reported for March, June, September and December/ Not Seasonally Adjusted
Standard and Poor's 500 index	Federal Reserve Bank of St. Louis (FRED), URL: http://research.stlouisfed.org/fred2/series/SP500/downloaddata?cid=32255	Index
US Consumer Price Index (CPI)	*International Financial Statistics,* International Monetary Fund, Washington D.C..	Index(1970=100) -Data available are monthly period averages. -Quarterly averages of monthly data are computed.
Oil price (West Texas Intermediate (WTI) monthly)	*International Financial Statistics,* International Monetary Fund, Washington D.C..	U.S. dollars per barrel -Data available are monthly period averages. -Quarterly averages of monthly data are computed after deflating the variable by CPI.
Kilian Index The variable is not country-specific	Updated version of the index of global real economic activity in industrial commodity markets, proposed in "Not all oil price shocks are alike ...", monthly, 1968.1-2009.2 URL: http://www-personal.umich.edu/~lkilian/reaupdate.txt	Index -Quarterly averages of monthly data are computed.
China's imports (Main	*International Financial Statistics,* International Monetary Fund,	Million US dollar

Variable	Source	Remarks
Land)	Washington D.C..	-Data available are monthly period averages. -Quarterly averages of monthly data are computed.
China's exports (Main Land)	*International Financial Statistics,* International Monetary Fund, Washington D.C..	Million US dollar -Data available are monthly period averages. -Quarterly averages of monthly data are computed.
World's imports	*International Financial Statistics,* International Monetary Fund, Washington D.C..	Billion US dollar -Data available are monthly period averages. -Quarterly averages of monthly data are computed.
World's exports	*International Financial Statistics,* International Monetary Fund, Washington D.C..	Billion US dollar -Data available are monthly period averages. -Quarterly averages of monthly data are computed.
US productivity index (real GDP/total employment)	DataStream: OECD Economic Outlook	Quarterly Index (2005=100) /Seasonally adjusted
All Europe Countries (aggregate) productivity index (real GDP/total employment)	DataStream: OECD Economic Outlook	Quarterly Index (2005=100) /Seasonally adjusted
Households and Non-profit Organizations; Total Assets	B(100) Balance Sheet of Households and Non-profit Organizations, Federal Reserve Bank, Flow of Funds Accounts of the United States, URL: http://www.federalreserve.gov/datadownload/Choose.aspx?rel=Z.1	Multiplier: 1000000 Not Seasonally Adjusted (Data are on quarterly basis which is the lowest frequency available)
Households and Non-profit Organizations; Total Liabilities	B(100) Balance Sheet of Households and Non-profit Organizations, Federal Reserve Bank, Flow of Funds Accounts of the United States, URL: http://www.federalreserve.gov/datadownload/Choose.aspx?rel=Z.1	Multiplier: 1000000 Not Seasonally Adjusted (Data are on quarterly basis which is the lowest frequency available)
Households and Non-profit organizations; disposable personal income (NIPA)	B(100) Balance Sheet of Households and Non-profit Organizations, Federal Reserve Bank, Flow of Funds Accounts of the United States, URL: http://www.federalreserve.gov/datadownload/Choose.aspx?rel=Z.1	Multiplier: 1000000 Seasonally Adjusted (Data are on quarterly basis which is the lowest frequency available)
WTI Daily	DataStream	Crude Oil-WTI Spot Cushing U$/BBL

Variable	Source	Remarks
	Note: Data are available starting 10/01/1983.	
Brent Daily	DataStream Note: Data are available starting 04/01/1982.	Crude Oil-Brent Cur. Month FOB U$/BBL
Dubai Daily	DataStream Note: Data are available starting 29/01/1986.	Crude Oil-Arab Gulf Dubai FOB U$/BBL

Appendix 3-2

Table A3-1: Values for the Results Presented in Figure 3-8: Direct Impact on the Ratio of the US Current Account to GDP Ratio from the 6x6 VAR (Othogonalized Impulse Response Functions (OIRF))

	impulse = US Federal-Debt-held-by-the-Public-to-GDP ratio, and response = US CA-to-GDP ratio			impulse = Log of CPI-deflated S&P 500 index (first differenced), and response = US CA-to-GDP ratio		
step	OIRF	S.E.	t-statistic	OIRF	S.E.	t-statistic
0	0	0		0	0	
1	0.000628***	0.000215	***2.92093***	-0.0016***	0.000297	***-5.39731***
2	0.000649**	0.00027	***2.403704***	-0.00185***	0.000363	***-5.09917***
3	0.000545*	0. 0003	***1.816667***	-0.00177***	0.000399	***-4.43609***
4	0.000437	0.000327	*1.336391*	-0.00163***	0.000419	***-3.89976***
5	0.000349	0.000354	*0.985876*	-0.00151***	0.000434	***-3.47235***
6	0.000282	0.000381	*0.740157*	-0.0014***	0.000447	***-3.12752***
7	0.000231	0.000409	*0.564792*	-0.00131***	0.000459	***-2.84314***
8	0.000192	0.000436	*0.440367*	-0.00122**	0.000472	***-2.59322***
9	0.000162	0.000462	*0.350649*	-0.00115**	0.000483	***-2.38095***
10	0.000138	0.000486	*0.283951*	-0.00108**	0.000495	***-2.18586***
11	0.000119	0.000509	*0.233792*	-0.00102**	0.000506	***-2.01383***
12	0.000104	0.00053	*0.196226*	-0.00096*	0.000517	***-1.85493***
13	0.000092	0.000549	*0.167577*	-0.0009*	0.000528	***-1.71023***
14	0.000082	0.000566	*0.144876*	-0.00085	0.000538	*-1.58178*
15	0.000075	0.000582	*0.128866*	-0.0008	0.000548	*-1.46168*
16	0.000069	0.000597	*0.115578*	-0.00075	0.000558	*-1.35125*
17	0.000065	0.00061	*0.106557*	-0.00071	0.000568	*-1.24824*
18	0.000062	0.000622	*0.099678*	-0.00067	0.000578	*-1.15571*
19	0.00006	0.000632	*0.094937*	-0.00063	0.000588	*-1.06803*
20	0.000059	0.000642	*0.0919*	-0.00059	0.000598	*-0.98997*
21	0.000059	0.000651	*0.09063*	-0.00056	0.000607	*-0.91928*
22	0.000059	0.000659	*0.08953*	-0.00053	0.000616	*-0.8539*
23	0.000059	0.000666	*0.088589*	-0.0005	0.000626	*-0.79233*
24	0.00006	0.000673	*0.089153*	-0.00047	0.000635	*-0.73701*
25	0.000062	0.000679	*0.091311*	-0.00044	0.000643	*-0.6874*
26	0.000063	0.000685	*0.091971*	-0.00042	0.000652	*-0.6411*
27	0.000065	0.00069	*0.094203*	-0.0004	0.000661	*-0.59909*
28	0.000067	0.000694	*0.096542*	-0.00038	0.000669	*-0.56203*
29	0.000069	0.000699	*0.098712*	-0.00036	0.000677	*-0.52733*
30	0.000071	0.000703	*0.100996*	-0.00034	0.000685	*-0.49635*
31	0.000073	0.000706	*0.103399*	-0.00032	0.000692	*-0.46821*
32	0.000075	0.00071	*0.105634*	-0.00031	0.0007	*-0.44143*

The values of the OIRF and SE are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.

(*), (**) and (***) indicate the 10%, 5% and 1% significance levels.

Table A3-1: Values for the Results Presented in Figure 3-8: Direct Impact on the Ratio of the US Current Account (CA) to GDP Ratio from the 6x6 VAR (Othogonalized Impulse Response Functions (OIRF)) (Continued)

	impulse = Log of the Real Oil Price, and response = US CA-to-GDP ratio			impulse = KI, and response = US CA-to-GDP ratio		
step	OIRF	S.E.	t-statistic	OIRF	S.E.	t-statistic
0	0	0		0	0	
1	0.000326*	0.000173	***1.884393***	0.000039	0.000185	*0.210811*
2	0.000765***	0.000276	***2.771739***	0.000063	0.000307	*0.205212*
3	0.001116***	0.000358	***3.117318***	0.00013	0.000408	*0.318627*
4	0.001366***	0.000419	***3.260143***	0.000228	0.000488	*0.467213*
5	0.001537***	0.000467	***3.291221***	0.000339	0.000551	*0.615245*
6	0.001651***	0.000507	***3.25641***	0.000449	0.0006	*0.748333*
7	0.001727***	0.000543	***3.180479***	0.00055	0.000638	*0.862069*
8	0.001777***	0.000575	***3.090435***	0.000639	0.000668	*0.956587*
9	0.001807***	0.000606	***2.981848***	0.000714	0.000692	*1.031792*
10	0.001824***	0.000637	***2.863422***	0.000775	0.000711	*1.090014*
11	0.001832***	0.000669	***2.738416***	0.000823	0.000726	*1.133609*
12	0.001832**	0.000701	***2.613409***	0.00086	0.000738	*1.165312*
13	0.001827**	0.000736	***2.482337***	0.000887	0.000747	*1.187416*
14	0.001818**	0.000773	***2.351876***	0.000906	0.000754	*1.201592*
15	0.001805**	0.000812	***2.222906***	0.000917	0.000759	*1.208169*
16	0.00179**	0.000854	***2.096019***	0.000922	0.000762	*1.209974*
17	0.001773*	0.000899	***1.972191***	0.000923	0.000764	*1.208115*
18	0.001755*	0.000947	***1.853221***	0.000919	0.000765	*1.201307*
19	0.001736*	0.000998	***1.739479***	0.000912	0.000766	*1.190601*
20	0.001716	0.001051	*1.632731*	0.000902	0.000766	*1.177546*
21	0.001695	0.001106	*1.53255*	0.00089	0.000766	*1.16188*
22	0.001675	0.001163	*1.440241*	0.000877	0.000766	*1.144909*
23	0.001655	0.001222	*1.354337*	0.000862	0.000766	*1.125326*
24	0.001635	0.001283	*1.274357*	0.000847	0.000767	*1.104302*
25	0.001615	0.001345	*1.200743*	0.000831	0.000769	*1.080624*
26	0.001595	0.001408	*1.132813*	0.000815	0.000771	*1.057069*
27	0.001576	0.001472	*1.070652*	0.000798	0.000774	*1.031008*
28	0.001558	0.001536	*1.014323*	0.000782	0.000778	*1.005141*
29	0.00154	0.001601	*0.961899*	0.000766	0.000783	*0.978289*
30	0.001523	0.001666	*0.914166*	0.00075	0.00079	*0.949367*
31	0.001507	0.001732	*0.870092*	0.000735	0.000797	*0.922208*
32	0.001491	0.001798	*0.829255*	0.00072	0.000805	*0.89441*

The values of the OIRF and SE are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.

(*), (**) and (***) indicate the 10%, 5% and 1% significance levels.

Table A3-1: Values for the Results Presented in Figure 3-8: Direct Impact on the Ratio of the US Current Account (CA) to GDP Ratio from the 6x6 VAR (Othogonalized Impulse Response Functions (OIRF)) (Continued)

	impulse = China variable, and response = US CA-to-GDP ratio		
step	OIRF	S.E.	t-statistic
0	0	0	
1	-9.3E-05	0.000173	*-0.53757*
2	-0.00019	0.000271	*-0.70849*
3	-0.00021	0.000345	*-0.61449*
4	-0.00016	0.0004	*-0.4075*
5	-7.1E-05	0.000443	*-0.16027*
6	0.000045	0.000482	*0.093361*
7	0.00017	0.000519	*0.327553*
8	0.000297	0.000557	*0.533214*
9	0.00042	0.000597	*0.703518*
10	0.000537	0.000638	*0.841693*
11	0.000646	0.000681	*0.948605*
12	0.000747	0.000727	*1.02751*
13	0.00084	0.000774	*1.085271*
14	0.000925	0.000824	*1.122573*
15	0.001002	0.000876	*1.143836*
16	0.001073	0.00093	*1.153763*
17	0.001136	0.000986	*1.15213*
18	0.001193	0.001043	*1.143816*
19	0.001245	0.001103	*1.12874*
20	0.001291	0.001164	*1.109107*
21	0.001332	0.001227	*1.085575*
22	0.001369	0.001292	*1.059598*
23	0.001402	0.001358	*1.032401*
24	0.001432	0.001426	*1.004208*
25	0.001457	0.001494	*0.975234*
26	0.00148	0.001564	*0.946292*
27	0.0015	0.001635	*0.917431*
28	0.001518	0.001707	*0.889279*
29	0.001533	0.001779	*0.86172*
30	0.001546	0.001852	*0.834773*
31	0.001557	0.001926	*0.808411*
32	0.001567	0.002001	*0.783108*

The values of the OIRF and SE are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.
(*), (**) and (***) indicate the 10%, 5% and 1% significance levels.

Appendix 3-3

Table A3-2: Values for the Results Presented in Figure 3-9: Indirect Impact on the Ratio of the US Current Account (CA) to GDP Ratio from the 6x6 VAR (Othogonalized Impulse Response Functions (OIRF))

	impulse = Log of CPI-deflated S&P 500 index (first differenced), and response = US Federal-Debt-held-by-the-Public-to-GDP Ratio			impulse =Log of the real oil price, and response = US Federal-Debt-held-by-the-public-to-GDP Ratio		
step	OIRF	S.E.	t-statistic	OIRF	S.E.	t-statistic
0	0	0		0	0	
1	-0.00243***	0.000695	***-3.49353***	0.000897*	0.000459	***1.954248***
2	-0.00362***	0.001045	***-3.46794***	0.002317***	0.000839	***2.761621***
3	-0.00433***	0.001326	***-3.26244***	0.003897***	0.001181	***3.299746***
4	-0.00479***	0.00159	***-3.01132***	0.005479***	0.001505	***3.640532***
5	-0.00511***	0.00185	***-2.7627***	0.00699***	0.001824	***3.832237***
6	-0.00534**	0.002109	***-2.53248***	0.008396***	0.002145	***3.914219***
7	-0.0055**	0.002366	***-2.32502***	0.009683***	0.002472	***3.917071***
8	-0.00561**	0.00262	***-2.14084***	0.010847***	0.002806	***3.865645***
9	-0.00567*	0.002868	***-1.97768***	0.01189***	0.003145	***3.780604***
10	-0.0057*	0.003111	***-1.83189***	0.01282***	0.00349	***3.673352***
11	-0.0057*	0.003348	***-1.70131***	0.013642***	0.00384	***3.552604***
12	-0.00567	0.003577	*-1.58429*	0.014367***	0.004194	***3.425608***
13	-0.00562	0.003799	*-1.47828*	0.015001***	0.004554	***3.294027***
14	-0.00555	0.004013	*-1.38226*	0.015553***	0.00492	***3.161179***
15	-0.00546	0.004219	*-1.29509*	0.016031***	0.005292	***3.029289***
16	-0.00537	0.004418	*-1.21526*	0.016442***	0.005674	***2.897779***
17	-0.00526	0.004611	*-1.14162*	0.016794***	0.006065	***2.769002***
18	-0.00515	0.004796	*-1.07402*	0.017092***	0.006468	***2.642548***
19	-0.00503	0.004975	*-1.01166*	0.017343**	0.006885	***2.518954***
20	-0.00491	0.005149	*-0.95378*	0.017551**	0.007319	***2.398005***
21	-0.00479	0.005318	*-0.90015*	0.017721**	0.00777	***2.280695***
22	-0.00466	0.005481	*-0.85057*	0.017858**	0.00824	***2.167233***
23	-0.00454	0.005641	*-0.80429*	0.017966**	0.008732	***2.05749***
24	-0.00441	0.005797	*-0.76126*	0.018048*	0.009245	***1.95219***
25	-0.00429	0.00595	*-0.72118*	0.018107*	0.009782	***1.851053***
26	-0.00417	0.006099	*-0.68405*	0.018147*	0.010341	***1.754859***
27	-0.00406	0.006246	*-0.64922*	0.01817*	0.010924	***1.66331***
28	-0.00394	0.006391	*-0.6168*	0.018178	0.01153	*1.576583*
29	-0.00383	0.006533	*-0.58671*	0.018173	0.012159	*1.494613*
30	-0.00373	0.006674	*-0.55859*	0.018157	0.01281	*1.417408*
31	-0.00363	0.006812	*-0.53244*	0.018132	0.013482	*1.344904*
32	-0.00353	0.006949	*-0.50799*	0.0181	0.014175	*1.276896*

The values of the OIRF and SE are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.
(*), (**) and (***) indicate the 10%, 5% and 1% significance levels.

Table A3-2: Values for the Results Presented in Figure 3-9: Indirect Impact on the Ratio of the US Current Account (CA) to GDP Ratio from the 6x6 VAR (Othogonalized Impulse Response Functions (OIRF)) (Continued)

	impulse = KI, and response = US Federal-Debt-held-by-the-Public-to-GDP Ratio			impulse = China variable, and response = US Federal-Debt-held-by-the-Public-to-GDP Ratio		
step	OIRF	OIRF	OIRF	OIRF	S.E.	t-statistic
0	0	0	0	0	0	
1	-0.00058	0.000481	*-1.19751*	0.002202***	0.000428	***5.14486***
2	-0.00099	0.000902	*-1.09978*	0.003834***	0.000774	***4.953488***
3	-0.00117	0.001295	*-0.90425*	0.005163***	0.001077	***4.793872***
4	-0.00113	0.001674	*-0.67204*	0.006317***	0.001364	***4.631232***
5	-0.00089	0.002047	*-0.43527*	0.007359***	0.00165	***4.46***
6	-0.00052	0.002421	*-0.21272*	0.008322***	0.001946	***4.276465***
7	-3.6E-05	0.002798	*-0.01287*	0.009226***	0.002255	***4.091353***
8	0.000509	0.003178	*0.160164*	0.010081***	0.002579	***3.908879***
9	0.00109	0.003556	*0.306524*	0.010891***	0.002919	***3.731072***
10	0.001685	0.003932	*0.428535*	0.011659***	0.003274	***3.561087***
11	0.002276	0.0043	*0.529302*	0.012387***	0.003645	***3.398354***
12	0.00285	0.004658	*0.611851*	0.013075***	0.004032	***3.242808***
13	0.003396	0.005003	*0.678793*	0.013724***	0.004435	***3.094476***
14	0.003909	0.005332	*0.733121*	0.014335***	0.004855	***2.952626***
15	0.004384	0.005644	*0.776754*	0.014909***	0.005292	***2.817271***
16	0.004819	0.005938	*0.811553*	0.015445***	0.005748	***2.687022***
17	0.005214	0.006212	*0.839343*	0.015946**	0.006223	***2.56243***
18	0.005569	0.006467	*0.861141*	0.016412**	0.006718	***2.442989***
19	0.005885	0.006702	*0.878096*	0.016845**	0.007235	***2.328265***
20	0.006164	0.006917	*0.891138*	0.017246**	0.007772	***2.218991***
21	0.006408	0.007113	*0.900886*	0.017615**	0.008332	***2.114138***
22	0.00662	0.007291	*0.907969*	0.017956**	0.008914	***2.014359***
23	0.006801	0.007451	*0.912763*	0.018269*	0.00952	***1.919013***
24	0.006955	0.007596	*0.915613*	0.018555*	0.010148	***1.828439***
25	0.007084	0.007727	*0.916785*	0.018816*	0.010799	***1.742384***
26	0.00719	0.007845	*0.916507*	0.019054	0.011474	*1.660624*
27	0.007275	0.007951	*0.914979*	0.01927	0.012171	*1.583272*
28	0.007342	0.008048	*0.912276*	0.019465	0.01289	*1.510085*
29	0.007393	0.008138	*0.908454*	0.01964	0.013632	*1.440728*
30	0.00743	0.008222	*0.903673*	0.019798	0.014395	*1.375339*
31	0.007455	0.008301	*0.898085*	0.019938	0.015178	*1.313612*
32	0.007468	0.008378	*0.891382*	0.020063	0.015981	*1.255428*

The values of the OIRF and SE are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.
(*), (**) and (***) indicate the 10%, 5% and 1% significance levels.

Table A3-2: Values for the Results Presented in Figure 3-9: Indirect Impact on the Ratio of the US Current Account (CA) to GDP Ratio from the 6x6 VAR (Othogonalized Impulse Response Functions (OIRF)) (Continued)

	impulse = Log of the Real Oil Price, and response = Log of CPI-deflated S&P 500 index (first differenced)		
step	OIRF	S.E.	t-statistic
0	0	0	
1	-0.00715**	0.003298	***-2.16768***
2	-0.00693**	0.003176	***-2.18105***
3	-0.00518**	0.002599	***-1.99346***
4	-0.0034	0.002176	*-1.56434*
5	-0.0019	0.001932	*-0.98137*
6	-0.00066	0.001793	*-0.36698*
7	0.000365	0.001715	*0.212828*
8	0.001223	0.001685	*0.725816*
9	0.001953	0.001699	*1.1495*
10	0.002583	0.00175	*1.476*
11	0.00313*	0.00183	***1.710383***
12	0.003609*	0.00193	***1.869948***
13	0.004028*	0.002043	***1.97161***
14	0.004396**	0.002163	***2.032362***
15	0.00472**	0.002285	***2.065646***
16	0.005003**	0.002406	***2.079385***
17	0.00525**	0.002526	***2.078385***
18	0.005466**	0.002642	***2.068887***
19	0.005653**	0.002754	***2.052651***
20	0.005815**	0.002864	***2.030377***
21	0.005954**	0.002971	***2.004039***
22	0.006073*	0.003077	***1.973676***
23	0.006173*	0.003182	***1.939975***
24	0.006258*	0.003288	***1.903285***
25	0.006328*	0.003397	***1.86282***
26	0.006386*	0.00351	***1.819373***
27	0.006432*	0.003629	***1.772389***
28	0.006468*	0.003754	***1.722962***
29	0.006496*	0.003887	***1.671212***
30	0.006517	0.004028	*1.617925*
31	0.00653	0.004179	*1.562575*
32	0.006538	0.004341	*1.506105*

The values of the OIRF and SE are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.
(*), (**) and (***) indicate the 10%, 5% and 1% significance levels.

Table A3-2: Values for the Results Presented in Figure 3-9: Indirect Impact on the Ratio of the US Current Account (CA) to GDP Ratio from the 6x6 VAR (Othogonalized Impulse Response Functions (OIRF)) (Continued)

	impulse = KI, and response = Log of the Real Oil Price			impulse = China variable, and response = Log of the Real Oil Price		
step	OIRF	S.E.	t-statistic	OIRF	S.E.	t-statistic
0	0	0		0	0	
1	0.016552*	0.008356	***1.980852***	0.017631**	0.007678	***2.296301***
2	0.026564**	0.013333	***1.99235***	0.02951**	0.011516	***2.562522***
3	0.031253*	0.016173	***1.932418***	0.036061***	0.013258	***2.719943***
4	0.032395*	0.017664	***1.833956***	0.038866***	0.01401	***2.774161***
5	0.031384*	0.01832	***1.7131***	0.039283***	0.014398	***2.728365***
6	0.029162	0.018451	*1.580511*	0.038257**	0.014705	***2.601632***
7	0.026329	0.018239	*1.443555*	0.0364**	0.015033	***2.42134***
8	0.023255	0.017794	*1.306901*	0.034096**	0.015414	***2.212015***
9	0.020164	0.017189	*1.173076*	0.031582**	0.015853	***1.992178***
10	0.017185	0.016477	*1.042969*	0.029004*	0.016352	***1.773728***
11	0.014391	0.015696	*0.916858*	0.026448	0.016909	*1.564137*
12	0.011817	0.014879	*0.794207*	0.023967	0.017522	*1.367823*
13	0.009478	0.014053	*0.674447*	0.02159	0.018186	*1.187177*
14	0.007375	0.013241	*0.556982*	0.019334	0.018894	*1.023288*
15	0.005499	0.012464	*0.441191*	0.017206	0.019638	*0.876158*
16	0.003839	0.011741	*0.326974*	0.015209	0.020413	*0.745064*
17	0.00238	0.01109	*0.214608*	0.013341	0.021208	*0.629055*
18	0.001106	0.010524	*0.105093*	0.0116	0.022017	*0.526866*
19	1.60E-06	0.010056	*0.000159*	0.00998	0.022833	*0.437087*
20	-0.00095	0.009695	*-0.09799*	0.008476	0.023649	*0.358408*
21	-0.00176	0.009444	*-0.18657*	0.007084	0.024457	*0.289651*
22	-0.00245	0.009301	*-0.26352*	0.005797	0.025253	*0.229557*
23	-0.00303	0.009261	*-0.32696*	0.004609	0.026032	*0.177051*
24	-0.00351	0.009311	*-0.37676*	0.003514	0.02679	*0.131168*
25	-0.0039	0.009438	*-0.41322*	0.002507	0.027522	*0.091091*
26	-0.00422	0.009626	*-0.43788*	0.001583	0.028226	*0.056083*
27	-0.00446	0.00986	*-0.45264*	0.000735	0.028899	*0.025433*
28	-0.00465	0.010125	*-0.45946*	-4.1E-05	0.029539	*-0.00139*
29	-0.00479	0.010411	*-0.46009*	-0.00075	0.030145	*-0.02488*
30	-0.00488	0.010705	*-0.45624*	-0.0014	0.030716	*-0.04551*
31	-0.00494	0.011	*-0.44909*	-0.00199	0.03125	*-0.06362*
32	-0.00496	0.011288	*-0.43976*	-0.00252	0.031749	*-0.0795*

The values of the OIRF and SE are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.
(*), (**) and (***) indicate the 10%, 5% and 1% significance levels.

Appendix 3-4

Table A3-3: The All-Variables-in-Level 6x6 Reduced-Form VAR Results

Equation /lagged value of:	US Current-Account-to-GDP Ratio	US Federal-Debt-held-by-the-Public-to-GDP Ratio	Log of S&P 500 Deflated By CPI	Log of the Real Oil Price	KI	China Variable
US Current-Account-to-GDP Ratio	0.8340201***	0.4168186***	-0.6482494	2.423849	-2.010784	-0.0844047*
	13.96	***3.41***	*-0.61*	*1.01*	*-1.15*	***-1.93***
US Federal-Debt-held-by-the-Public-to-GDP Ratio	0.0187197*	0.9361972***	0.2731903	-0.5407085	-0.0829305	0.0076585
	1.73	***42.33***	*1.42*	*-1.24*	*-0.26*	*0.97*
Log of S&P 500 Deflated By CPI	-0.0080025***	-0.0216073***	0.9829409***	0.0978331	-0.1713363**	-0.0068192***
	-3.11	***-4.1***	***21.47***	*0.94*	***-2.27***	***-3.61***
Log of the Real Oil Price	0.0050996***	0.0121357***	-0.0868143***	0.6630088***	-0.0918522*	0.0015655
	2.86	***3.32***	***-2.73***	***9.23***	***-1.75***	*1.2*
KI	-0.003242	-0.016399***	0.0425776	0.2154271**	0.8543733***	-0.0002347
	-1.39	***-3.44***	*1.03*	***2.3***	***12.48***	*-0.14*
China variable	-0.2840238***	0.2337556	1.400575	9.854202**	-0.9953489	0.7080839***
	-2.84	*1.14*	*0.79*	***2.45***	*-0.34*	***9.66***
Trend	0.000231***	0.0002858	-0.0008997	-0.0053715	0.0035506	0.0002901***
	2.64	*1.6*	*-0.58*	*-1.53*	*1.38*	***4.52***
Constant	0.0041459	0.0857596***	0.1711092	0.6321322	0.6555963**	0.0063486
	0.41	***4.15***	*0.95*	*1.55*	***2.21***	*0.86*
Number of Parameters	8	8	8	8	8	8
Root Mean Square Error (RMSE)	0.003607	0.007376	0.064149	0.145103	0.105914	0.002646
R-sq	0.956	0.9894	0.979	0.8951	0.8041	0.9897
chi2	2173.542	9369.148	4659.54	853.6135	410.3533	9575.708
Number of Observations	100	100	100	100	100	100

Data are quarterly.

The values of the estimates are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.

(*), (**) and (***) indicate the 10%, 5% and 1% significance levels of the variables.

Appendix 3-5

Table A3-4: The Alternate Wealth Variable 6x6 Reduced-Form VAR Results

Equation /lagged value of:	US Current-Account-to-GDP Ratio	US Federal-Debt-held-by-the-Public-GDP Ratio	US Household-Net-Wealth-to-Disposable-Income Ratio	Log of the Real Oil Price	KI	China variable
US Current-Account-to-GDP Ratio	0.835348***	0.293803**	-5.92159**	4.19451*	-0.01347	-0.06138
	13.48	***2.56***	***-2.45***	***1.75***	*-0.01*	*-1.31*
US Federal-Debt-held-by-the-Public-GDP Ratio	0.016344	0.930496***	0.90781**	-0.52174	-0.14489	0.005511
	1.5	***46.12***	***2.13***	*-1.23*	*-0.45*	*0.67*
US Household-Net-Wealth-to-Disposable-Income Ratio	-0.00344***	-0.01506***	0.93483***	0.1235**	0.016145	-0.00193*
	-2.65	***-6.28***	***18.5***	***2.46***	*0.42*	***-1.97***
Log of the Real Oil Price	0.005525***	0.013838***	-0.16352**	0.649984***	-0.09137*	0.001832
	3.05	***4.13***	***-2.31***	***9.26***	***-1.7***	*1.34*
KI	-0.00135	-0.00781*	0.053327	0.143052	0.840549***	0.000772
	-0.54	***-1.7***	*0.55*	*1.48*	***11.38***	*0.41*
China variable	-0.18771**	0.300182*	-0.53423	11.40961***	4.077883	0.823638***
	-2.19	***1.89***	*-0.16*	***3.43***	*1.6*	***12.69***
Trend	8.06E-05	2.44E-05	-0.0003	-0.00557***	-0.00192	0.000137***
	1.48	*0.24*	*-0.14*	***-2.64***	*-1.19*	***3.33***
Constant	-0.00535	0.077123***	0.152448	0.508207	0.18779	-0.00469
	-0.6	***4.71***	*0.44*	*1.48*	*0.71*	*-0.7*
Number of Parameters	8	8	8	8	8	8
Root Mean Square Error (RMSE)	0.003651	0.006751	0.142411	0.141534	0.108505	0.00276
R-sq	0.9549	0.9912	0.9296	0.9002	0.7944	0.9888
chi2	2119.19	11203.69	1321.056	902.3136	386.2667	8792.237
Number of Observations	100	100	100	100	100	100

Data are quarterly.

The values of the estimates are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.

(*), (**) and (***) indicate the 10%, 5% and 1% significance levels of the variables.

Appendix 3-6

Table A3-5: The 7x7 Reduced-Form VAR Results (First Case)

	US Current-Account-to-GDP Ratio	US Federal-Debt-held-by-the-Public-GDP Ratio	Log of S&P 500 deflated by CPI (first differenced)	Log of the Real Oil Price	KI	China variable	US-EU Productivity Differential
US Current-Account-to-GDP Ratio	0.9327661***	0.5867338***	-0.8590096	0.2105562	-1.224076	-0.0529162	0.1987251***
	16.38	***4.46***	*-0.8*	*0.08*	*-0.65*	*-1.1*	***3.42***
US Federal-Debt-held-by-the-Public-GDP Ratio	0.0165106	0.9387244***	0.2891726	-0.3715919	-0.0057324	0.0096197	-0.0342987***
	1.56	***38.39***	*1.44*	*-0.8*	*-0.02*	*1.07*	***-3.17***
Log of S&P 500 deflated by CPI (first differenced)	-0.0290204***	-0.0394496***	0.2379086**	0.3298509	-0.1506108	0.0026912	-0.0088089
	-5.55	***-3.27***	***2.4***	*1.44*	*-0.88*	*0.61*	*-1.65*
Log of the Real Oil Price	0.0027574	0.0081391**	-0.0693457**	0.6752137***	-0.1160428**	0.0014267	-0.0041849**
	1.57	***2.01***	***-2.09***	***8.82***	***-2.02***	*0.96*	***-2.34***
KI	0.000529	-0.0112661**	0.0104572	0.1767057*	0.8746359***	-0.0006398	0.0046321**
	0.24	***-2.17***	*0.25*	***1.8***	***11.85***	*-0.34*	***2.02***
China variable	-0.0129376	0.8171815***	1.165831	5.541241*	2.850461	0.8502863***	0.2595556***
	-0.18	***4.87***	*0.85*	***1.75***	*1.2*	***13.84***	***3.5***
US-EU Productivity Differential	-0.0478807	0.0751993	0.7974894	2.683671	1.77749	0.0709605	0.7451385***
	-0.82	*0.55*	*0.72*	*1.05*	*0.92*	*1.43*	***12.43***
Trend	-0.0000209	-0.0004304***	-0.0014413	-0.0031704	-0.0024125	0.0000631	0.0000624
	-0.45	***-4.00***	*-1.63*	*-1.56*	*-1.58*	*1.6*	*1.31*
Constant	0.0358813	-0.0290055	-0.6716682	-1.718546	-1.398468	-0.0775367	0.2593949***
	0.65	*-0.23*	*-0.64*	*-0.71*	*-0.77*	*-1.65*	***4.58***
Number of Parameters	9	9	9	9	9	9	9
Root Mean Square Error (RMSE)	0.003301	0.007618	0.06251	0.144074	0.108391	0.002793	0.00337
R-sq	0.9636	0.9889	0.215	0.8977	0.797	0.9886	0.977
chi2	2645.415	8874.583	27.39188	877.9141	392.6481	8679.655	4249.317
Number of Observations	100	100	100	100	100	100	100

Data are quarterly.

The values of the estimates are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.

(*), (**) and (***) indicate the 10%, 5% and 1% significance levels of the variables.

Appendix 3-7

Table A3-6: The 7x7 Reduced-Form VAR Results (Second Case)

	US Current-Account-to-GDP Ratio	US Federal-Debt-held-by-the-Public-GDP Ratio	Log of S&P 500 deflated by CPI (first differenced)	US-EU Productivity Differential	Log of the Real Oil Price	KI	China variable
US Current-Account-to-GDP Ratio	0.9327661***	0.5867338***	-0.8590096	0.1987251***	0.2105562	-1.224076	-0.0529162
	16.38	***4.46***	*-0.8*	***3.42***	*0.08*	*-0.65*	*-1.1*
US Federal-Debt-held-by-the-Public-GDP Ratio	0.0165106	0.9387244***	0.2891726	-0.0342987***	-0.3715919	-0.0057324	0.0096197
	1.56	***38.39***	*1.44*	***-3.17***	*-0.8*	*-0.02*	*1.07*
Log of S&P 500 deflated by CPI (first differenced)	-0.0290204***	-0.0394496***	0.2379086**	-0.0088089	0.3298509	-0.1506108	0.0026912
	-5.55	***-3.27***	***2.4***	*-1.65*	*1.44*	*-0.88*	*0.61*
US-EU Productivity Differential	-0.0478807	0.0751993	0.7974894	0.7451385***	2.683671	1.77749	0.0709605
	-0.82	*0.55*	*0.72*	***12.43***	*1.05*	*0.92*	*1.43*
Log of the Real Oil Price	0.0027574	0.0081391**	-0.0693457**	-0.0041849**	0.6752137***	-0.1160428**	0.0014267
	1.57	***2.01***	***-2.09***	***-2.34***	***8.82***	***-2.02***	*0.96*
KI	0.000529	-0.0112661**	0.0104572	0.0046321**	0.1767057*	0.8746359***	-0.0006398
	0.24	***-2.17***	*0.25*	***2.02***	***1.8***	***11.85***	*-0.34*
China variable	-0.0129376	0.8171815***	1.165831	0.2595556***	5.541241*	2.850461	0.8502863***
	-0.18	***4.87***	*0.85*	***3.5***	***1.75***	*1.2*	***13.84***
Trend	-0.0000209	-0.0004304***	-0.0014413	0.0000624	-0.0031704	-0.0024125	0.0000631
	-0.45	***-4.00***	*-1.63*	*1.31*	*-1.56*	*-1.58*	*1.6*
Constant	0.0358813	-0.0290055	-0.6716682	0.2593949***	-1.718546	-1.398468	-0.0775367
	0.65	*-0.23*	*-0.64*	***4.58***	*-0.71*	*-0.77*	*-1.65*
Number of Parameters	9	9	9	9	9	9	9
Root Mean Square Error (RMSE)	0.003301	0.007618	0.06251	0.00337	0.144074	0.108391	0.002793
R-sq	0.9636	0.9889	0.215	0.977	0.8977	0.797	0.9886
chi2	2645.415	8874.583	27.39188	4249.317	877.9141	392.6481	8679.655
Number of Observations	100	100	100	100	100	100	100

Data are quarterly.

The values of the estimates are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.

(*), (**) and (***) indicate the 10%, 5% and 1% significance levels of the variables.

Appendix 3-8

Table A3-7: The Detrended Variables 6x6 Reduced-Form VAR Results (First Case)

Equation /lagged value of:	US Current-Account-to-GDP Ratio (Detrended)	US Federal-Debt-held-by-the-Public-GDP Ratio (Detrended)	Log of S&P 500 deflated by CPI (Detrended)	Log of the Real Oil Price (Detrended)	KI	China variable (Detrended)
US Current-Account-to-GDP Ratio (Detrended)	0.830799***	0.381169***	-0.53992	2.498019	-2.12014	-0.08805**
	13.85	***2.72***	*-0.5*	*1.04*	*-1.2*	***-1.99***
US Federal-Debt-held-by-the-Public-GDP Ratio (Detrended)	0.018968*	0.938944***	0.264844	-0.54642	-0.0745	0.00794
	1.74	***36.93***	*1.35*	*-1.25*	*-0.23*	*0.99*
Log of S&P 500 deflated by CPI (Detrended)	-0.00809***	-0.02258***	0.985884***	0.099848	-0.17431**	-0.00692***
	-3.13	***-3.73***	***21.13***	*0.96*	***-2.29***	***-3.62***
Log of the Real Oil Price (Detrended)	0.004469***	0.005152	-0.06559**	0.677538***	-0.11327**	0.000851
	2.64	*1.3*	***-2.15***	***10.0***	***-2.28***	*0.68*
KI	-0.00158	0.002014	-0.01337	0.177119**	0.910854***	0.00165
	-0.92	*0.5*	*-0.43*	***2.57***	***18.03***	*1.3*
China variable (Detrended)	-0.28739***	0.196538	1.513663	9.931634**	-1.10951	0.704274***
	-2.86	*0.84*	*0.84*	***2.47***	*-0.38*	***9.49***
Constant	0.000305	0.002717	-0.0001	0.000586	0.000479	0.00002
	0.87	***3.29****	*-0.01*	*0.04*	*0.05*	0.08
Number of Parameters	7	7	7	7	7	7
Root Mean Square Error (RMSE)	0.003608	0.008437	0.065047	0.144581	0.106115	0.002666
R-sq	0.9242	0.986	0.9409	0.8149	0.8012	0.9097
chi2	1218.472	7059.165	1592.817	440.1812	402.9517	1007.686
Number of Observations	100	100	100	100	100	100

Data are quarterly.

The values of the estimates are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.

(*), (**) and (***) indicate the 10%, 5% and 1% significance levels of the variables.

Appendix 3-9

Table A3-8: The Detrended Variables 6x6 Reduced-Form VAR Results (Second Case)

Equation /lagged value of:	US Current-Account-to-GDP Ratio (Detrended)	US Federal-Debt-held-by-the-Public-GDP Ratio (Detrended)	Log of S&P 500 deflated by CPI (Detrended)	Log of the Real Oil Price (Detrended)	KI	China variable (Detrended)
US Current-Account-to-GDP Ratio (Detrended)	0.8223972	0.3074076	-0.5376847	2.068545	-2.327819	-0.1228178
	13.1*	***1.86****	*-0.5*	*0.84*	*-1.3*	***-3.17*****
US Federal-Debt-held-by-the-Public-GDP Ratio (Detrended)	0.0193454	0.9464391	0.2542302	-0.4167955	-0.0325374	0.0158408
	1.69*	***31.39*****	*1.3*	*-0.93*	*-0.1*	***2.24*****
Log of S&P 500 deflated by CPI (Detrended)	-0.0084571	-0.0256373	0.9862705	0.0895001	-0.180529	-0.0079325
	-3.15**	***-3.62*****	***21.41*****	*0.85*	***-2.36*****	***-4.79*****
Log of the Real Oil Price (Detrended)	0.003723	0.0010833	-0.0773504	0.6703929	-0.1255312	-0.0006293
	2.01**	*0.22*	***-2.43*****	***9.2*****	***-2.37*****	*-0.55*
KI	0.000205	0.009151	0.024352	0.1442491	0.9270003	0.0024132
	0.11	***1.81****	*0.74*	***1.91****	***16.93*****	***2.03*****
China variable (Detrended)	-0.3576484	-0.5996375	2.377986	3.978631	-3.338911	0.2898798
	-2.25**	*-1.43*	*0.87*	*0.64*	*-0.74*	***2.95*****
Constant	0.0003618	0.0029899	0.0009091	0.000155	0.0011137	0.0001
	0.99	***3.11*****	*0.15*	*0.01*	*0.11*	*0.34*
Number of Parameters	7	7	7	7	7	7
Root Mean Square Error (RMSE)	0.003714	0.009796	0.063791	0.145681	0.105901	0.002294
R-sq	0.9168	0.9804	0.8959	0.6097	0.802	0.5478
chi2	1102.302	5008.72	860.9779	156.2342	404.9919	121.1572
Number of Observations	100	100	100	100	100	100

Data are quarterly.

The values of the estimates are in a roman font. The t-statistics are in italics and the significant t-statistics are in bold italics.

(*), (**) and (***) indicate the 10%, 5% and 1% significance levels of the variables.