Oil Shocks and External Balances

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Abstract: This paper estimates the effects of demand and supply shocks in the global crude oil market on several measures of oil exporters’ and oil importers’ external balance, including the oil trade balance, the non-oil trade balance, the current account, capital gains, and changes in net foreign assets (NFA). Our first result is that the effect of oil demand and supply shocks on the merchandise trade balance and the current account, which depending on the source of the shock can be large, depends critically on the response of the non-oil trade balance. Our estimates of the response of the non-oil trade balance provide a benchmark for models of the international transmission of these shocks under incomplete markets. Second, we document the presence of potentially large and systematic valuation effects in response to these shocks. Valuation effects overall tends to cushion the effect of oil demand and supply shocks on the NFA positions of oil exporters and oil importers. Third, we quantify the overall importance of oil-market specific demand and supply shocks for external balances. We find, for example, that these shocks jointly account for about half of the variation in oil exporters’ changes in NFA, whereas demand shocks associated with the global business cycle account for an additional one third.

JEL Codes: F32, F36, O16, O57, Q43

Key Words: Oil prices; external adjustment; oil demand; oil supply; international financial integration; valuation effects.

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1. Introduction

A large literature has investigated the macroeconomic impact of oil-price shocks, focusing in particular on the response of real economic growth and consumer price inflation in oil-importing countries (see Barsky and Kilian (2004) and Hamilton (2005) for recent reviews). A much smaller literature including, for example, Bruno and Sachs (1982), Ostry and Reinhart (1992), and Gavin (1990, 1992) has studied the impact of oil price shocks on external accounts. This relative neglect of the external channels of the transmission of oil price shocks does not reflect a lack of interest in this question. On the one hand, a common premise in policy discussions is that oil price shocks have large and often harmful effects on external accounts, forcing countries to borrow from abroad to offset adverse terms-of-trade shocks. On the other hand, it is sometimes suggested that there is not enough international risk sharing. In that view, the ensuing imbalances may not be large enough to cushion the domestic impact of oil price shocks effectively. Thus, it is interesting from both a policy and a theoretical point of view to investigate and to quantify the impact of oil price shocks on external balances.

Recent developments in the crude oil market and the emergence of large global external imbalances have reignited the long-standing policy discussion about the role of oil prices in determining external balances (see, e.g., Rebucci and Spatafora 2006). There is renewed interest in the question of how oil revenues will be recycled in the global economy, along with the recognition that the impact of disturbances in the crude oil market on oil-importing economies depends in part on how increased oil-export revenues are recycled through international trade in goods and assets. Our paper provides the most comprehensive analysis to date of the relationship between oil prices and external balances. Drawing on new data sets and on methodologies that until recently were not available, we document the dynamic effects of demand and supply shocks in the global crude oil market on external balances of oil-exporting and oil-importing economies during 1975–2006. The paper also examines the changing importance of these shocks over time by means of historical decompositions, and it uses variance decompositions as a measure of the average importance of these shocks for external balances.

Our analysis departs from the existing literature in several dimensions. First, we avoid some of the methodological drawbacks of earlier studies by exploiting recent advances in the measurement of shocks in the oil market (see Kilian 2008c). We not only control for reverse
causality from global macroeconomic aggregates to the real price of oil, but we also differentiate between different sources of variation in the real price of oil. Our analysis illustrates the importance of distinguishing between oil price changes driven by crude oil supply shocks, by oil-market specific demand shocks (such as changes in the precautionary demand for crude oil) and by innovations to the demand for all industrial commodities driven by the global business cycle.

Second, previous studies tended to focus exclusively on the trade balance and the current account. In this paper, we further differentiate between the effects of shocks in the crude oil market on the oil-trade balance and the non-oil trade balance, highlighting the role of the non-oil trade balance in offsetting oil trade deficits. Estimates of the response of the non-oil trade balance shed light on the degree to which international financial markets are incomplete and thus provide a useful benchmark for the design of theoretical models of the transmission of oil demand and supply shocks under incomplete markets. We also consider the effects of such shocks on the valuation of net foreign assets (NFA). The existence of valuation effects in general has been documented by Lane and Milesi-Ferretti (2007) and Gourinchas and Rey (2007) for the United States and other countries. In this paper, we address the complementary question of whether there are systematic valuation effects in response to oil demand and oil supply shocks that help financially integrated economies cope with oil trade imbalances.

Third, previous studies focused on selected oil-importing advanced economies. While that focus was appropriate in the context of these earlier studies, it leaves many questions unanswered. For example, how do oil exporters respond to oil demand and supply shocks? How do trade balances in Japan and Europe respond to such shocks compared to the United States? In order to answer these questions our paper takes a wider perspective. In addition to the economies of Japan, of the Euro area and of the United States individually, we consider broad aggregates of oil importing and oil exporting economies. This approach allows us to interpret our empirical results in light of recent theoretical advances (i) in modeling oil demand and oil supply shocks in the two-country dynamic stochastic general equilibrium (DSGE) framework (see Bodenstein, Erceg, and Guerrieri 2008), and (ii) in modeling valuation effects in incomplete markets (see Ghironi, Lee and Rebuschi 2007; Devereux and Sutherland 2008). Empirical evidence on the responses of external balances is especially important because theory puts few restrictions on these responses. Similarly, the analysis of the role of valuation effects in the international
transmission of shocks is still in its infancy.

The main results of our analysis are as follows. The first set of results relates to the response of the trade accounts of oil importers and oil exporters to the demand and supply shocks that drive the real price of oil. Each of the three demand and supply shocks in the global crude oil market that we consider has distinct effects on external balances. For example, the effect of an oil supply disruption on the oil trade balance tends to be small, short-lived and statistically insignificant, consistent with the estimated response of the price of oil. In contrast, an unexpected increase in demand for crude oil causes a persistent, large and statistically significant oil trade deficit. Similarly, the timing, magnitude and even direction of other components of the current account tend to differ with the type of shock. The overall effect of oil demand and supply shocks on the trade balance depends critically on the response of the non-oil trade balance. Whereas the theoretical literature has tended to focus on the limiting cases of financial autarky or complete markets, our estimates of the responses of the non-oil trade balance provide evidence of considerable, but not perfect international financial market integration. Our empirical results also highlight systematic differences in the responsiveness of the U.S., European and Japanese oil trade balance to oil demand and oil supply shocks. Japan is the most exposed to such shocks, and the United States is the least affected.

The second set of results relates to the capital gains and losses triggered by the same shocks. Using the Lane and Milesi-Ferretti (2007) NFA data set, we document the presence of potentially large and systematic valuation effects in response to oil demand and supply shocks for broad aggregates of oil importers and oil exporters. Valuation effects manifest themselves in capital gains or capital losses. Our analysis suggests that these capital gains and losses play an important role in explaining the dynamics of changes in NFA positions, making it necessary to consider the degree of international financial integration of a country and the structure of its foreign asset holdings and liabilities in predicting the effect of such shocks. We conclude that international financial integration has tended to cushion the effect of oil demand and supply shocks on the change in NFA positions of oil importers and oil exporters overall, although there is greater variation at the level of individual countries.

Third, we quantify the importance of global business cycle demand shocks as well as oil-specific demand and supply shocks for external balances. We provide evidence, for example, that these shocks jointly account for 82% of the variation in oil exporters’ changes in NFA
(expressed as a share of GDP). Oil-market specific demand and supply shocks jointly account for about half of the variation, whereas demand shocks associated with the global business cycle account for an additional one third.

The remainder of the paper is organized as follows. Section 2 motivates our focus on demand and supply shocks in the crude oil market and describes the econometric methodology used in this study. Section 3 discusses the data. Section 4 reviews the mechanisms by which shocks to oil demand and oil supply are expected to drive external balances, drawing on recent work by Bodenstein et al. (2008), Ghironi et al. (2007) and Devereux and Sutherland (2008). Section 5 reports the estimation results. Section 6 contains our conclusions.

2. Empirical Methodology

Theoretical models of the effect of oil price shocks on the economy in general (and on external accounts in particular) have typically been constructed under the premise that one can think of varying the price of crude oil, while holding all other variables in the model constant. In other words, oil prices are treated as exogenous with respect to the global economy. This premise is not credible (see, e.g., Barsky and Kilian 2002, 2004; Hamilton 2003). There are good theoretical reasons and there is strong empirical evidence that global macroeconomic fluctuations influence the real price of crude oil (see Kilian 2008a,b,c). For example, it is widely accepted that a global business cycle expansion (as in recent years) tends to raise the real price of oil.\(^1\) The fact that the same economic shocks that drive macroeconomic aggregates (and thus external accounts) also may drive the price of crude oil makes it impossible to separate cause and effect in studying the effect of higher oil prices on external accounts without a structural model of oil prices.

A second limitation of standard theoretical models is the implicit premise that the effect of an exogenous change in the price of crude oil will be the same, regardless of which demand or supply shocks in the oil market are responsible for this change. This premise is questionable. Since oil price shocks historically have been driven by varying combinations of oil demand and oil supply shocks, their effect on external aggregates is bound to be different from one period to the next. Indeed, this fact helps account for the apparent instability in the reduced form relationship between oil prices and the macroeconomy. Recent work by Kilian (2008c) and

\(^1\) As noted by Hamilton (2005), “it is clear … that demand increases rather than supply reductions have been the primary factor driving oil prices over the last several years.”
Kilian and Park (2007) has shown that the effects of demand and supply shocks in the crude oil market on U.S. macroeconomic aggregates are qualitatively and quantitatively different, depending on whether the oil price increase is driven by a booming world economy (resulting in high demand for all industrial commodities including crude oil), by a disruption of global crude oil production, or by shifts in precautionary demand for crude oil that reflect increased concerns about future oil supply shortfalls (also see Alquist and Kilian 2007). It is quite natural to expect similar differences in the effect of these shocks on external accounts. In this section, we outline an empirical methodology that addresses both of these concerns and allows us to assess empirically the effect of oil demand and oil supply shocks on external balances.

Our empirical approach involves two main steps. The first step is to trace fluctuations in the real price of crude oil to the underlying demand and supply shocks in the crude oil market. The second step is to assess empirically the responses of external accounts of selected countries and country groups to the demand and supply shocks in the crude oil market identified in the first step. To the extent that the latter shocks are predetermined with respect to macroeconomic aggregates and external accounts, standard regression methods can be used to estimate the responses of external accounts by country or region and to determine the extent to which historical fluctuations in external accounts were driven by the cumulative effect of specific demand and supply shocks in the crude oil market.

2.1. Construction of the Demand and Supply Shocks in the Crude Oil Market

Our approach closely follows the identification strategy of Kilian (2008c). We estimate a structural VAR model based on monthly data for the vector time series $z_t$, consisting of the percent change in global crude oil production, $a$ (suitably detrended) measure of global real economic activity in industrial commodity markets, and the real price of crude oil. The VAR model allows for two years’ worth of lags. The structural VAR representation of the model is

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2 Analogous approaches have been employed in Kilian and Park (2007) for studying the effect of oil demand and oil supply shocks on U.S. stock markets and in Kilian (2007) for studying the relationship between the U.S. retail gasoline market and the global crude oil market. A similar model has also been employed by Bodenstein et al. (2008) for studying quarterly U.S. trade balances.

3 The term real economic activity in this paper is understood to refer to real economic activity that affects industrial commodity markets rather than the usual broader concept of real economic activity underlying world real GDP or industrial output. This distinction is necessary because an increase in value added in the service sector, for example, is likely to have a very different effect on global demand for industrial commodities than an increase in manufacturing. The index of global real economic activity in industrial commodity markets is constructed from representative single voyage freight rates collected by Drewry Shipping Consultants Ltd. for various bulk dry
where \( \varepsilon_t \) denotes the vector of serially and mutually uncorrelated structural innovations. The structural innovations are derived by imposing exclusion restrictions on \( A_0^{-1} \) in \( \varepsilon_t = A_0^{-1} \varepsilon_t \). We attribute fluctuations in the real price of oil to three structural shocks: \( \varepsilon_{1t} \) denotes shocks to the global supply of crude oil (henceforth “oil supply shock”); \( \varepsilon_{2t} \) captures shocks to the global demand for all industrial commodities (including crude oil) that are driven by global real economic activity (“aggregate demand shock”)\(^4\); and \( \varepsilon_{3t} \) denotes an oil-market specific demand shock. The latter shock is designed to capture shifts in precautionary demand for crude oil that reflect increased concerns about future oil supply shortfalls that are by construction orthogonal to the other shocks (“oil-specific demand shock”), although there are other possible interpretations. We discuss the interpretation of this oil-market specific demand shock in more detail in section 4, where we link its interpretation to various theoretical models of the crude oil market and make the case that this shock can effectively be viewed as a precautionary demand shock.

Following Kilian (2008c), we assume that (1) oil producers are free to respond to lagged values of oil prices, real activity, and oil production in setting oil supply, but will not respond to oil demand shocks within the same month, given the costs of adjusting oil production and the uncertainty about the state of the crude oil market; (2) that increases in the real price of oil driven by demand shocks that are specific to the oil market will not lower global real economic activity in industrial commodity markets within the month; and (3) that innovations to the real price of oil that cannot be explained by oil supply shocks or aggregate demand shocks must be demand shocks that are specific to the oil market. These assumptions imply a recursively identified model of the form:

\[
A_0 z_t = \alpha + \sum_{i=1}^{24} A_0 z_{t-i} + \varepsilon_t,
\]

cargoes such as coal, iron ore, fertilizer, and scrap metal. For a full discussion of the rationale and construction of this index see Kilian (2008c). Unlike alternative measures of monthly global real activity such as indices of OECD industrial production, this index captures the recent surge in demand for industrial commodities from emerging economies such as China and India.

\(^4\) The term “aggregate demand” as used here differs from the concept of aggregate demand in macroeconomics textbooks. Rather it refers to shifts in the demand for all industrial commodities reflecting the global business cycle.
This structural model postulates that that real price of oil (conditional on lagged values of all variables) is determined by the intersection of the demand curve for crude oil and the supply curve of crude oil. Oil demand shocks do not shift the oil supply curve, but move the demand curve along the supply curve, causing the real price of oil to change. The model also allows for oil supply shocks (say an unexpected oil supply disruption caused by a war or driven by an exogenous political decision) to move the vertical supply curve along the downward sloping demand curve, again causing the price of oil to change. Thus, all three shocks are allowed to affect the real price of oil within a given month. The model further imposes that the shifts in the real price of oil triggered by oil-market specific demand shocks will not affect global aggregate demand within the same month. This assumption is consistent with the sluggish response of real aggregates to shocks in oil markets documented in the related literature.

The assumption of a vertical short-run supply curve of crude oil is consistent with anecdotal evidence. Global oil supply undoubtedly responds to oil demand shocks. The assumption of a one-month delay in that response is consistent with the observation that oil producers only infrequently update forecasts of oil demand. The reason for the slow response of oil supply to oil demand shocks is that changing oil supply is costly. Oil producers will respond to a change in trend demand, once recognized, but, in practice, determining a change in trend requires a long time span of data. When in doubt, oil producers will wait until enough information has accumulated rather than rush to changing supply immediately in response to news about the economy. In fact, anecdotal evidence from the early 1980s suggests that Saudi Arabia was extremely slow to adjust to the realities of reduced demand during the Volcker recession. Moreover, there is no evidence that oil producers are adjusting supply within the same month in response to announcements about global macro developments. The few historical instances in which countries such as Saudi Arabia moved quickly in response to news events were reactions to adverse oil supply shocks (such as the Iranian Revolution), not examples of responses to shifts in the demand for oil.
The response of the real price of oil to the three structural shocks \( \varepsilon_j, j = 1, 2, 3 \), is reported in Figure 1. There are striking differences in the timing, persistence, and magnitude of the response depending on the source of the shock. An unanticipated increase in oil-market specific demand (such as an increase in precautionary demand for oil) causes an immediate and persistent increase in the real price of oil characterized by overshooting; an unanticipated increase in aggregate demand for all industrial commodities causes a delayed, but sustained increase in the real price of oil; and an unanticipated oil supply disruption causes a transitory increase in the real price of oil within the first year.

Using the fitted values of model (1) we can decompose the fluctuations in the real price of oil at each point in time into components representing the cumulative effect of all shocks of a given type up to this date (see Figure 2). The historical decomposition of the real price of oil in Figure 2 suggests that major oil price surges typically have been driven by a combination of aggregate demand shocks and precautionary demand shocks, rather than oil supply shocks. For example, the increase in the real price of oil after 2003 was driven mostly by the cumulative effects of positive global aggregate demand shocks.

In this paper, we are interested in assessing the effect of these crude oil demand and crude oil supply shocks on external imbalances. Whereas the shocks implied by the VAR model are measured at monthly frequency, international data on external accounts for most countries are available only at annual frequency. Following a similar procedure in Kilian (2008c), we deal with this problem by constructing measures of the annual shocks as averages of the monthly structural innovations for each year:

\[
\hat{\varepsilon}_{ji} = \frac{1}{12} \sum_{t=1}^{12} \hat{\varepsilon}_{j,t}, \quad j = 1, \ldots, 3,
\]

where \( \hat{\varepsilon}_{j,t} \) refers to the estimated residual for the \( j \)th structural shock in the \( t \)th month of the \( t \)th year of the sample. Although data for \( z_t \) are available as far back as 1973, we lose two years worth of observations in estimating the VAR model. Thus, the resulting annual shock series extends back only as far as 1975. Figure 3 plots \( \hat{\varepsilon}_{ji}, j = 1, 2, 3 \). The pattern of shocks in the late 1970s and in the 1980s in particular is consistent with additional evidence about the genesis of the second oil crisis presented in Barsky and Kilian (2002, 2004). For example, the oil price shock of 1979/80 is the result of the superimposition of three large positive aggregate demand
shocks in 1978, 1979, and 1980, a one-time spike in oil-specific demand in 1979 (at the time of the Iranian Revolution, the Iranian hostage crisis and the Soviet invasion of Afghanistan) and an oil supply shock in 1980 (but interestingly not in 1979, as discussed in Kilian 2008a,c).

2.2. Estimation of the Dynamic Effects
Let $y_t$ denote a stationary macroeconomic aggregate of interest such as the share of the trade balance in GDP. We are interested in estimating the response of $y_t$ to demand and supply shocks in the crude oil market. We treat the shocks $\hat{\zeta}_{jt}$, $j = 1,...,3$, as predetermined with respect to $y_t$.

Predeterminedness rules out feedback from $y_t$ to the shocks $\hat{\zeta}_{jt}$, $j = 1,...,3$, within a given year $t$.\footnote{In contrast, strict exogeneity imposes in addition Granger non-causality from $y_t$ to $\hat{\zeta}_{jt}$. For further discussion see Cooley and LeRoy (1985). Pre-determinedness and strict exogeneity in our regression framework correspond to the notion of weak and strong exogeneity, respectively, in the parlance of Engle, Hendry and Richard (1983).} This assumption allows us to examine their dynamic effects on the dependent variable based on regressions of the form:

\[
y_t = \delta_j + \sum_{i=0}^h \psi_i \hat{\zeta}_{j,t-i} + u_{jt}, \quad j = 1,...,3
\]

where $u_{jt}$ is a potentially serially correlated error, and $\hat{\zeta}_{jt}$ is a serially uncorrelated shock. The parameter $h$ is chosen to coincide with the maximum horizon of the impulse response function to be computed. In practice, we set the maximum horizon of the impulse responses to five years.

By definition the impulse response is $dy_{t+1}/d \hat{\zeta}_{j,t}$. Differentiation yields that $dy_{t}/d \hat{\zeta}_{j,t}=\psi_{ij}$.

Under stationarity, it follows that $dy_{t}/d \hat{\zeta}_{j,t-1}=dy_{t+1}/d \hat{\zeta}_{j,t} = \psi_{ij}$.

Regression model (2) allows consistent estimation of the impulse responses under minimal assumptions. Our equation-by-equation approach is built on the premise that the shock series $\hat{\zeta}_{jt}$, $j = 1,...,3$, are mutually uncorrelated. Whereas the structural VAR residuals $\hat{\epsilon}_{jt}$, $j = 1,...,3$, are orthogonal by construction, the annual shocks $\hat{\zeta}_{jt}$, $j = 1,...,3$, which have been obtained by aggregating over time, need not be orthogonal. Table 1 shows that their contemporaneous correlation ranges from -0.11 to 0.07. Although inevitably there will be some omitted variable bias, these correlations are so low that not much is lost by treating the shocks as orthogonal.

We also investigated some alternative regression approaches. One alternative approach
would have been to estimate model (2) including current and lagged values of all shocks. That approach uses the same identifying assumptions as model (2), but would have been far less parsimonious. Another approach would have been to fit a recursively identified VAR model to \( \left( \hat{\mu}_1t, \hat{\mu}_2t, \hat{\mu}_3t, y_t \right)^t \) with a sufficiently high lag order. That more restrictive regression approach is practically feasible, but many of the response estimates are strongly counterintuitive and the estimation results are highly sensitive to the lag structure, suggesting that the model structure is rejected by the data or – more likely – that there is a serious overfitting problem. A third alternative would have been to add lagged dependent variables as regressors in the model (2). The latter specification would have required strict exogeneity of \( \hat{\mu}_y \) with respect to \( y_t \), which is not a viable assumption in our context (see Kilian 2008a,b,c). For these reasons, we report results based on the parsimonious equation-by-equation approach based on model (2).

3. Data

In the empirical analysis we consider six different measures of external balance. The specific measures of external balance used are:

- Change in Net Foreign Assets \( \equiv \) Current Account + Capital Gains
- Current Account = Merchandise Trade Balance + Service Trade Balance + Income Balance
  - Merchandise Trade Balance \( \equiv \) Oil Trade Balance + Non-Oil Merchandise Trade Balance
  - Oil Trade Balance
  - Non-Oil Merchandise Trade Balance
- Capital Gains on Gross Foreign Assets and Liabilities.

In what follows, the trade balance should be understood to refer to the merchandise trade balance. The trade balance does not include trade in services because of data availability and concerns about the poor quality of trade data on services. For the same reasons, we also exclude the income balance, whose response, in any case, would be difficult to interpret without further knowledge of countries’ asset positions. A more detailed description of these aggregates is provided in the Data Appendix. The NFA data are from Lane & Milesi-Ferretti (2007). All other data (including the trade balance, current account, and GDP data) are from the IMF’s *World Economic Outlook* database.
Our analysis focuses on the following countries and country groupings:

1. Major oil exporters
2. High-income oil-importing economies
   - United States
   - Euro Area
   - Japan

A country is classified as a *major oil exporter* if its average share of fuel exports in total exports during 1970-2005 is at least 20 percent. Fuel exports include petroleum products, natural gas and coal.6 We exclude Canada and the U.K. because these countries are likely to behave differently from both oil-importing advanced economies and from major oil exporters. Both countries have diversified export structures with fuel shares of less than 20 percent, but their oil exports are large in absolute value during the sample period. In contrast, the oil export share of Norway is high enough for the country to qualify as a major oil exporter. The Euro area for the purpose of the paper includes 12 high-income oil-importing European countries.7 In additional sensitivity analysis we extended the sample of oil importing economies to include middle-income countries. The results are very similar and are omitted to conserve space.8

All external accounts are expressed in current dollars. As is conventional, all external accounts are normalized by nominal GDP for the empirical analysis. Shares in GDP for the groups are not computed by averaging shares across countries, but by adding external accounts across countries and normalizing them by the sum of GDP in current dollars of the same countries. This procedure has the advantage of netting out intra-group imbalances.

4. Theoretical Background

A number of theoretical studies have examined the impact of oil price shocks on external

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6 The list of major oil exporters includes Algeria, Angola, Azerbaijan, Bahrain, Brunei, Congo (Rep. of), Ecuador, Gabon, Indonesia, Iran, Kazakhstan, Kuwait, Libya, Mexico, Nigeria, Norway, Oman, Qatar, Russia, Saudi Arabia, Syria, Trinidad and Tobago, Turkmenistan, the United Arab Emirates, Venezuela, and Yemen.

7 The Euro area includes Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain.

8 Middle-income economies were classified as developing countries that lie above the median of the PPP-weighted GDP per capita of the sample of all developing economies excluding China and India. We did not investigate low-income countries given the poor quality of these countries’ external accounts data. We also excluded China and India. The Chinese economy underwent major structural changes during the sample period, making it difficult to interpret the responses. We did not include results for India, because India, given its size and position in the income distribution, is not representative of either low or middle income economies.
accounts, holding everything else constant. While this earlier literature provides a useful framework for thinking about the effects of an exogenous shift in oil prices, it is of limited use for our purposes because (1) it does not allow for endogenous responses of the real price of oil to the global economy, (2) because it does not distinguish between demand and supply shocks in the crude oil market, and (3) because it does not take into account the degree of international financial integration and the international portfolio structure of oil importing and oil exporting economies.

Instead in this paper, we build on recent advances in the theoretical literature that incorporate the distinction between demand and supply shocks in the global crude oil market that is central to our analysis. The theoretical analysis most closely related to our paper is Bodenstein et al. (2008), who in turn build on the open economy model of Backus and Crucini (1998). In their two-country model, each country produces a distinct tradable good, which is used as an input in the production of consumption and investment goods both at home and abroad. Crude oil serves as an input in the production of the domestic tradable good. It also enters directly into the household consumption bundle. One country is an oil-importer, reflecting its relatively low oil endowment, whereas the other country is an oil-exporter. There are convex costs to adjusting the share of oil in production and consumption that drive a wedge between the short-run and the long-run elasticity of oil demand. Financial markets are incomplete in the baseline model, but the case of complete markets is discussed as well.

Our analysis also is guided by recent empirical and theoretical work that stresses the role of valuation effects in the external adjustment of economies (see, e.g., Lane and Milesi-Ferretti 2007; Gourinchas and Rey 2007; Ghironi et al. 2007; Devereux and Sutherland 2008). Whereas the traditional “trade” (or macroeconomic) channel of adjustment to external shocks works through changes in the quantities and prices of goods exported and imported and is reflected in the response of the trade accounts, the “financial” (or valuation) channel of adjustment stressed in the recent literature works through changes in external portfolio positions and asset prices and is reflected in income flows and in valuation changes, conditional on an economy’s initial gross foreign asset and foreign liability position.

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9 Sen (1994) provides an overview of various channels of transmission. Rebucci and Spatafora (2006) discuss the global transmission of oil-price shocks to macroeconomic and financial variables.
This section reviews the predictions of economic theory for the response of external balances to oil demand and oil supply shocks. Section 4.1 outlines the implications of the Bodenstein et al. (2008) model for the real price of oil. Section 4.2 explains why the distinction between oil demand and oil supply shocks matters for not just for the real price of oil, but for external balances as well. Section 4.3 describes the responses of oil importers’ and oil exporters’ trade accounts in the bilateral setting of Bodenstein et al. (2008). Section 4.4 predicts the corresponding valuation effects based on the theoretical channel of transmission highlighted by Ghironi et al. (2007) and Devereux and Sutherland (2008) as well as data on the gross foreign asset and liability holdings of major oil exporters.

4.1. Implications of Economic Theory for the Response of the Real Price of Oil

Bodenstein et al. (2008) discuss within the context of their DSGE model the effects of several distinct demand and supply shocks in the crude oil market. In order to build intuition, it is useful to review first the implications of each of these shocks for the real price of oil.

**Oil supply shocks**

The case of an oil supply disruption is easiest to analyze, because we can think of the oil supply shock as occurring exogenously with respect to the world economy. Hence, the response to an oil supply disruption is analogous to the response to an exogenous oil price increase. The only question is what the dynamic pattern of the real price of oil in response to this oil supply shock looks like. Bodenstein et al. show that in their model the real price of oil exhibits a temporary increase in response to an oil supply disruption. Compared with standard models based on the counterfactual premise of exogenous oil prices, the oil price responses to an oil supply disruption are quantitatively smaller, but qualitatively similar, as shown in Bodenstein et al. (2008). The magnitude of the temporary increase in the real price of oil depends on the importance of oil in domestic production and the elasticity of substitution between oil and other factors of production. The larger the elasticity of substitution and the smaller the oil share, the flatter the overall response. Thus, the model is potentially consistent with a nearly flat response of the real price of oil. The model responses tend to be more sensitive to the choice of model parameters than in standard models with exogenous oil prices.

The estimated response of the real price of oil in Figure 1 is consistent with the prediction of the Bodenstein et al. model in that it exhibits a temporary increase in the real price of oil of
relatively small magnitude within the first year. The small magnitude of this response is suggestive of a world economy with large elasticities of substitution and/or low oil shares. This finding is consistent with related evidence in Edelstein and Kilian (2007a,b) as well as Kilian (2008a,b).

**Oil-market specific demand shocks**
Bodenstein et al. analyze the effect of an oil-specific demand shock modeled as an exogenous taste shock. Their example is the type of exogenous taste shock experienced by China after 2004, as households decided to replace bikes as their main means of transportation with cars. Since cars are complementary in use with oil, whereas bikes are not, this represents an exogenous increase in the demand for oil that is arguably orthogonal to fluctuations in overall demand for industrial commodities from China. Bodenstein et al. show that this oil-specific demand shock has similar effects and operates through the same channels as the oil supply shock discussed above. The qualitative characteristics of the response to an oil-specific demand shock that they derive in their model is fully consistent with our VAR response estimate in that the response jumps on impact and overshoots.

Although this type of taste shock is a natural candidate for interpreting the oil-specific demand shock in our VAR analysis, among a number of other candidates, it is not an empirically plausible candidate in our view. First, much of the variation in oil-specific demand occurred long before the Chinese economy began to transform itself and there is no evidence of similar taste shocks in other countries prior to 2004. Second, in order to generate the magnitude of the impact response of the price of oil in Figure 1 would require a taste shock too large to be plausible. Third, given the values for the elasticity of substitution and the oil share implied by our earlier analysis of oil supply disruptions, the response to a taste shock is likely to be small. Fourth, the historical decompositions in Figure 2 show no evidence that the increase in the real price of oil since 2004 was driven by oil-specific demand shocks. Finally, the observed increase in the price of oil since 2004 is simply too large to be plausibly explained based on taste shifts.

Another candidate explanation is weather shocks such as unexpectedly cold winters (that raise demand for heating oil and ultimately for crude oil) or perhaps the disruptions caused by Hurricanes Rita and Katrina. This explanation as well can be ruled out based on the observed pattern and timing of the shocks. Hurricanes Rita and Katrina, in particular, represented primarily a reduction in the demand for oil, as U.S. oil refineries shut down, because the
reduction in crude oil supply associated with these Hurricanes was negligible on a global scale. This situation has been analyzed in an extended VAR model in Kilian (2007) that takes account of the distinction between crude oil and retail gasoline. The VAR response estimates for the crude oil demand and crude oil supply shocks are very similar, so demand shocks at the retail end of the market are not an important factor for our analysis.

For these reasons, we focus on an alternative explanation. The observed response of the real price of oil in Figure 1 to an oil-specific demand shock is also consistent with the implications of models of precautionary demand. Precautionary demand arises from the uncertainty about shortfalls of expected supply relative to expected demand. It reflects the convenience yield from having access to inventory holdings of oil that can serve as insurance against an interruption of oil supplies. Such an interruption could arise because of concerns over unexpected growth of demand, over unexpected declines of supply, or over both. As shown in the theoretical analysis of Alquist and Kilian (2007), one can interpret precautionary demand shocks as arising from shifts in the conditional variance, as opposed to the conditional mean, of oil supply shortfalls. Such shifts in uncertainty may arise even controlling for the global business cycle and the global supply of crude oil. In response to an unexpected increase in uncertainty, the real price of oil jumps up on impact and overshoots, before reaching its new long-run equilibrium level. The similarity between this impulse response result derived in Alquist and Kilian (2007) and that derived in Bodenstein et al. (2008) is not surprising. Since precautionary demand shocks may be represented as preference shocks in the Bodenstein et al. framework, they can be analyzed in much the same way as foreign taste shocks.

Despite these similarities, there are several reasons why the oil-specific demand shock is more plausibly interpreted as a precautionary demand shock. First, there are no other obvious candidates for exogenous oil-market specific demand shocks. This is true for the explanation proposed above based on preference shocks in China, for the explanation based on weather, as well as for alternative explanations based on exogenous changes in crude oil inventory policies, which can be shown to lack empirical support. Second, the large impact effect of oil-market specific shocks documented in Figure 1 is difficult to reconcile with shocks not driven by expectation shifts. Third, the timing of the oil-specific demand shocks and the direction of their effects is consistent with the timing of exogenous events such as the outbreak of the Persian Gulf War that would be expected to affect uncertainty about future oil supply shortfalls on a priori
grounds. Fourth, the overshooting of the real price of oil in response to oil-market specific
demand shocks coincides with the predictions of theoretical models of precautionary demand
shocks driven by increased uncertainty about future oil supply shortfalls (see Alquist and Kilian
2007). Fifth, the movements in the real price of oil induced by this shock are highly correlated
with independent measures of the precautionary demand component of the real price of oil based
on the spread of oil futures prices. Using oil futures market data since 1989, Alquist and Kilian
(2007) show that this correlation may be as high as 80% notwithstanding the use of a completely
different data set and methodology.

Although our interpretation of the oil-specific demand shock is different from the
interpretation focused on in Bodenstein et al., the mechanics of how oil-market specific demand
shocks are transmitted in the model does not depend on the interpretation of the shock.

Aggregate demand shocks
Bodenstein et al. also discuss the possibility of a demand shock affecting all industrial
commodities across the board. For example, a foreign productivity shock would raise demand
not only for crude oil, but for all other industrial commodities. It is widely accepted that the
stellar growth in China, India and other emerging economies in recent years represents such an
aggregate demand shock. One key difference between aggregate demand shocks and other oil
demand or oil supply shocks is that aggregate demand shocks would have potentially important
effects on the oil-importing economy, even if the oil share in the economy were zero. Bodenstein
et al. conclude that, as there are a myriad of different shocks that affect aggregate demand, it is
difficult to predict the effect of such shocks on the real price of oil.

Even without a formal economic model, however, it is clear that the response of the price
of oil to an unanticipated increase in global aggregate demand depends on two opposing effects.
On the one hand, such a shock represents a stimulus for the oil-importing economy (quite
independently of the oil share). On the other hand, it has adverse consequences for oil-importing
economies in that it raises the price of oil. Which of these two effects dominates is an empirical
question. Related research by Kilian (2008c) suggests that within the first year of such a shock,
the stimulating effect on U.S. real GDP dominates, whereas subsequently the adverse effect
associated with higher oil prices dominates. This evidence is also consistent with the delayed
increase in the real price of oil observed in Figure 1 in response to a positive aggregate demand
shock. It is only with a considerable delay that the full effect of a positive aggregate demand
shock on the real price of oil makes itself felt.

4.2. Why the Distinction between Oil Demand and Oil Supply Shocks Matters for External Balances

The distinction between oil demand and oil supply shocks matters not just for the real price of oil, as shown in section 4.1, but for the dynamics of oil importer's and oil exporter's external balances. There are two distinct reasons why each oil demand and oil supply shock is expected to have different effects on external balances. First, as demonstrated in Figure 1, each shock has different implications for the timing, magnitude and persistence of the path of oil prices.

Consider, for example, a hypothetical oil price shock associated with higher energy demand in China. Suppose that this oil price shock arises because Chinese consumers develop a taste for cars as opposed to bicycles such that Chinese demand for energy increases, even holding Chinese output constant. It may seem at first that the responses of oil importing economies to the higher oil prices triggered by this oil-market specific demand shock should be no different from the response to higher oil prices triggered by an oil supply disruption. This conjecture ignores, however, that these two shocks involve potentially very different dynamic responses of the real price of oil (as illustrated in Figure 1). To the extent that the time path of changes in the real price of oil triggered by a (negative) oil supply shock looks different from the time path induced by a (positive) oil demand shock, the magnitude and timing of the resulting responses of external balances also will be different. Indeed, Bodenstein et al. document these differences in the context of their DSGE model. While the extent to which the theoretical responses differ in their analysis depends on necessarily ad hoc assumptions about the time series process driving the underlying oil demand and oil supply shocks, our empirical analysis allows us to recover these responses directly from the data.

The second reason one would expect the responses of external balances to differ depending on the underlying shock is that oil demand shocks may have effects on oil-importing economies that do not operate through the real price of oil. For example, an unanticipated expansion of global demand for industrial commodities will tend to stimulate the U.S. economy, as higher demand for industrial commodities goes hand in hand with higher demand for U.S. exports. Thus fluctuations in the global business cycle will have a direct stimulating effect on U.S. economic growth in addition to the indirect growth-retarding effect working through higher oil prices (and higher prices of other imported industrial commodities). The relative importance
of these effects varies over time, with the stimulating effect dominating in the short run (see Kilian 2008c). This means that the response of an oil-importing economy to an aggregate demand shock should differ systematically from the response to an oil supply shock that does not involve any direct effect on the economy. While global aggregate demand shocks have not been incorporated in the current generation of DSGE models of external balances, as stressed in Bodenstein et al. (2008), the effect of such a demand shock may diverge markedly from the response to an oil-specific demand shock (or an oil supply shock).

These two points also have important implications for applied work. To the extent that a given oil price change is a composite of several underlying oil demand and oil supply shocks, each of which induces different dynamics for the reasons discussed above, it can be very misleading to focus on the response of external balances to an average oil price shock. A case in point is the increase in the real price of oil since 2004. As shown in Figure 2, the increase was driven mainly by repeated positive aggregate demand shocks (reflecting primarily strong growth in countries such as India, China and other emerging economies). This explains why this particular oil price shock did not induce a sharp recession or stock market correction, as traditional models of oil price shocks would have suggested (see Kilian 2008c; Kilian and Park 2007). Thus, changes in the composition of oil price shocks (reflecting the time variation in oil demand and oil supply shocks) go a long way toward explaining the apparent instability of the statistical relationship between oil prices and macroeconomic aggregates. For the same reason one would expect no stable relationship between oil prices and external balances. Our analysis avoids this problem altogether by explicitly distinguishing between different oil demand and oil supply shocks.

4.3. Implications of Economic Theory for the Response of the Trade Account

With these insights in mind, we now review the implications of the DSGE model of Bodenstein et al. (2008) for the responses of the trade account to oil demand and oil supply shocks.

**Oil supply shocks**

The model in Bodenstein et al. (2007) makes several predictions about the response of external balances to oil supply disturbances that can be empirically evaluated. Under incomplete markets, an oil supply disruption generates an oil trade deficit and a non-oil surplus in the oil importing economy. The non-oil trade surplus (and the corresponding oil trade deficit) should be greater for
countries that do not produce oil domestically (such as Japan or the Euro area) than for countries that do rely in part on domestic oil production to meet their needs (such as the United States). In contrast, under complete markets, the non-oil trade balance of oil importers should remain unaffected by oil supply disruptions. The response of the oil-exporting economy will be the exact mirror image of that of the oil-importing economy by construction.

**Oil-market specific demand shocks**
The analysis in Bodenstein et al. suggests that the responses of external balances should be qualitatively (although not necessarily quantitatively) similar to the responses to an oil supply disruption. In particular, we would expect an oil trade deficit and non-oil trade surplus under incomplete markets, and an oil-trade deficit and a balanced non-oil trade account under complete markets.

**Aggregate demand shocks**
Although Bodenstein et al. do not report results for aggregate demand shocks, given the evidence in Kilian (2008c) and Kilian and Park (2007), one would expect the higher oil price triggered by a positive aggregate demand shock to cause an oil trade deficit that peaks only with a delay. The oil trade deficit will require a non-oil trade surplus to the extent that markets are not complete. The earlier comment about the magnitude of the oil trade deficit in the U.S. relative to that in more oil-dependent economies continues to apply. Independently of the effect working through higher oil prices, the direct stimulating effect on the oil-importing effect may amplify or weaken the non-oil trade surplus of oil importers, depending on the structure of world trade. Thus, theory predicts an oil trade deficit, but is consistent with either a non-oil trade surplus or a non-oil trade deficit.10

4.4. Implications of Economic Theory for the Response of Capital Gains
The valuation channel of adjustment relies on changes in asset prices and external portfolio positions in response to oil-demand and oil-supply shocks. The magnitude of this adjustment depends on countries’ initial gross foreign asset and foreign liabilities. Ghironi et al. (2007) and Devereux and Sutherland (2008) recently have illustrated the workings of the valuation channel in a standard two-country DSGE model with incomplete financial markets and a symmetric

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10 Moreover, since we cannot think of the resulting change in the real price of oil as occurring in isolation, the responses of the non-oil trade balance to an aggregate demand shock have no implications for the debate over incomplete versus complete markets.
configuration of gross foreign assets and liabilities. Although none of the oil demand and oil supply shocks considered in our paper have been modeled explicitly in that work, some intuition may be gained by treating an exogenous increase in the price of oil as negative aggregate productivity shock in the oil exporting country. Such an oil supply shock would cause asset prices to increase in the oil-exporting economy (and to fall in the oil-importing economy), thereby transferring some of the increased wealth associated with higher oil prices from oil exporters to oil importers. Such a shock would also cause the oil-exporting economy to run a trade surplus (and the oil-importing economy to run a trade deficit), at least initially, thereby changing the respective foreign asset holdings. As has been shown in this theoretical literature, the capital losses of oil exporters may easily more than offset the trade imbalance, resulting in a short-run loss of net foreign assets overall for oil exporters (and a gain for oil importers). In the long-run, however, asset prices return to their steady state value and the valuation channel vanishes.

The same intuition also applies to oil-specific demand shocks, except the dynamics may differ, reflecting the evolution of the real price of oil in response to oil-specific demand shocks. Thus, an implication of these models is that any oil demand and oil supply shock should cause a temporary capital loss in oil exporting countries to the extent that it raises the price of oil (and a corresponding capital gain in the rest of the world). Of course, as discussed earlier, aggregate demand shocks have additional effects on external balances not operating through the real price of oil, allowing for the ensuing capital gains and losses to be tempered or even reversed.

The simple prediction of a capital loss at least in response to negative oil supply shocks and positive oil-specific demand shocks ignores likely asymmetries in oil exporters’ and oil importers’ gross asset and liability positions. Given the relative weight of oil exporters and oil importers in world GDP (about 10% and 90%, respectively, in PPP terms), one would expect that the share of oil exporter’s asset holdings in the total asset holdings of oil importing economies must be rather small, whereas that of oil importers in the total asset holdings of oil exporting economies may be much larger. This reasoning suggests that the valuation effect should be larger for oil exporters than for oil importers, all else equal.

In the absence of detailed portfolio data for oil exporting economies it is difficult to assess the empirical content of this statement. If, however, we are willing to assume that oil exporters to do not hold foreign assets in other oil exporting economies (because those assets do
not allow diversification), we can compute aggregate gross foreign asset and liabilities for the aggregate of oil exporters defined earlier based on the data set of Lane and Milesi-Ferretti (2007). These data show that oil exporters on average held foreign assets valued at about 60% of their GDP over the sample period, compared with foreign liabilities of about 50% of GDP. For individual countries, we find much greater disparities. The data show that Saudi Arabia, for example, has foreign assets amounting to 101% of Saudi GDP on average over the sample period, but Saudi foreign liabilities are only 26% of GDP on average. These patterns are consistent with widespread anecdotal evidence of the recycling of oil revenues in the form of foreign asset acquisitions and support the hypothesis that oil importers’ capital gains should be smaller than oil exporters’ capital losses.

Even this prediction, however, ignores the important role of relative exchange rate adjustments triggered by a given oil demand or oil supply shock (also see the related evidence in Lane and Milesi-Ferretti 2007). Thus, one would not expect the stylized bilateral and symmetric model above to generate accurate predictions for specific oil-importing economies such as the United States or Japan. At best it may be representative for very broad aggregates of oil exporters and oil importers.

5. Estimation Results

Regression model (2) treats the oil demand and supply shocks $\hat{\zeta}_{jt}$, $j = 1,\ldots, 3$, as predetermined with respect to the dependent variable. Before discussing the estimation results, it is useful to assess the realism of this assumption. Although the assumption of predeterminedness is not testable, its plausibility may be judged based on the correlation of $\hat{\zeta}_{jt}$, $j = 1, 2$, with autoregressive innovations for U.S. external balances (expressed as a share of GDP). Clearly, the United States is the economy for which the assumption of predetermined external shocks is most likely to be invalid, given the overall size of the U.S. economy and its disproportionate contribution to the world economy. As Table 2 shows, nevertheless, innovations to the U.S. dependent variables are not very highly correlated with demand and supply shocks in the crude oil market at annual frequency, with the exception of the oil trade balance, which is highly negatively correlated with oil-specific demand shocks for the obvious reason that oil-market specific demand shocks raise the price of oil immediately causing the oil trade balance to
deteriorate on impact (see Figure 1). The low correlations for the second shock, in particular, are important because they dispel concerns that positive innovations to domestic real economic activity (reflected in a deterioration of the current account as a share of GDP) may drive aggregate demand innovations in global commodity markets. If there were such a causal link within the year, one would expect to see large negative correlations in column 2 of Table 2. Similarly, oil supply disruptions would be associated with large positive correlations in column 1 of Table 2. The actual correlations are quite moderate in most cases and often of the opposite sign. With the exception of the oil trade balance, the only positive correlations in column 1 are 0.09 and 0.00 and the largest (and only) negative correlation in column 2 is 0.02. While not dispositive, these results are consistent with the maintained assumption of predeterminedness.

5.1. Impulse responses

Figures 4-5 show the estimated responses of each measure of external balance by type of shock. All responses have been normalized such that a given shock will imply an increase in the real price of oil. The external balances are expressed as a share of GDP. The one-standard error bands for the impulse responses based on model (2) are constructed using a block bootstrap method that allows for serially correlated error terms (see Berkowitz, Birgean and Kilian 1999).

5.1.1. Major Oil Exporters

The aggregate of oil exporters in Figure 4 is of particular interest because the external accounts for the aggregate of oil exporters by construction are the mirror image of the external accounts of the rest of the world. For example, a surplus for oil exporters in Figure 4 is indicative of a deficit for the rest of the world by construction. Thus, the results in Figure 4 lend themselves to being interpreted in light of the bilateral theoretical model of oil exporters and oil importers in Bodenstein et al. (2008).\textsuperscript{11} As predicted by theory, oil demand and oil supply shocks have potentially very different implications for external balances; there are important differences in the timing, magnitude and sign of their effects on external balances.

Oil supply shock

Figure 4 shows an immediate, but short-lived and statistically insignificant oil trade surplus in

\textsuperscript{11} Although in the interest of conserving space we only report results for a broadly defined set of oil exporting economies, qualitatively similar results would be obtained if we focused on the subset of OPEC oil exporters.
oil-exporting countries. Consistent with the evidence in Figure 1, the oil trade surplus is largest in year 0. The non-oil trade balances shows little response initially followed by a marginally significant surplus three years later that is not predicted by the Bodenstein et al. model. The net effect on the merchandise trade balance and current account is an initial statistically insignificant surplus driven by the oil trade balance, followed by a return to balance in year 1 and 2. The statistically significant trade surplus in year 4 is driven by the unexpected response of the non-oil trade balance described above.

The last two columns of Figure 4 focus on the capital account. Although capital gains may be inferred from comparing the responses of the current account and of changes in NFA, we compute separate responses for capital gains. This facilitates the construction of confidence intervals for the response of capital gains. Oil exporters as a group experience a statistically significant short-run capital loss, consistent with the implications of the theoretical analysis in Ghironi et al. (2007) and Devereux and Sutherland (2008). The capital loss within the first year offsets the current account surplus with no change in NFA. Subsequent capital losses are only partially statistically significant and changes in NFA are generally not statistically significant.

**Oil-market specific demand shock**

Oil-specific demand shocks cause an immediate, highly significant and persistent oil trade surplus. The oil trade surplus peaks in year 1 and declines only slowly over time. It coincides with a persistent and partially significant non-oil trade deficit, suggesting a considerable degree of international financial integration. The net effect on the merchandise trade balance and current account is a highly significant temporary surplus. At the same time, oil exporters experience persistent and partially statistically significant capital losses in the first four years, resulting in a statistically significant accumulation of net foreign assets in years 0 and 1. Thereafter, the change in NFA is statistically indistinguishable from zero. As in the case of oil supply shocks, the capital gains response cushions the effect of the current account on the change in NFA.

**Aggregate demand shock**

The analysis of the responses to aggregate demand shocks is complicated by the fact that we cannot think of the change in the real price of oil as occurring in isolation. Figure 4 shows that a positive aggregate-demand shock causes a highly significant oil trade surplus in oil-exporting economies. The response is hump-shaped and peaks in year 2. At the same time, the non-oil
trade balances goes into deficit starting in year 1, but the non-oil trade deficit is only partially statistically significant. The net effect on the merchandise trade balance and current account is a temporary surplus that is statistically significant in years 2 and 3. The non-oil trade deficit is associated with persistent, although largely statistically insignificant, capital losses. Although the pattern of net foreign asset accumulation largely mirrors the current account, the capital losses systematically reduce the accumulation of net foreign assets.

5.1.2. High-Income Oil Importers
While the results in Figure 4 lend themselves to interpretations in light of economic theory, the data for oil exporters are of uneven quality. Thus, it is of interest to look at the same problem from the point of view of high-income oil-importing economies. Figure 5 focuses on an aggregate of advanced oil-importing economies consisting of the United States, Japan, and the Euro area. While these economies represent only a subset of oil importers, their data are of relatively high quality and they jointly represent a large share of world GDP.\footnote{Similar results would be obtained if we added middle-income oil-importing economies to this group.}

Oil supply shock
How does the aggregate of major oil importers’ external balances respond to an oil supply disruption? Figure 5 shows that an oil supply shock causes an immediate oil trade deficit in oil importing countries, but the deficit is small, short-lived and statistically insignificant. This result is consistent with the small response of the real price of oil documented in Figure 1. The fact that the oil trade deficit is only short-lived is consistent with the short-lived oil trade surplus in oil-exporting economies documented in Figure 4. Under incomplete markets, one would expect oil-importing countries to generate a non-oil trade surplus. Indeed, the non-oil trade balance in Figure 5 is in surplus for the first few years, although not significantly so. As a result, within the first three years neither the merchandise trade balance nor the current account is statistically different from zero. The data, however, reveal a clear pattern of valuation effects for oil importers in response to oil supply disruptions. There is a highly significant short-run capital loss, followed by largely insignificant capital gains in years 3 and 4. The capital loss causes an overall loss of net foreign assets that is especially pronounced on impact and one year after the supply shock. Unlike the corresponding capital loss in Figure 4, this capital loss is not consistent with the stylized bilateral theoretical models of the valuation effect discussed in section 4.4. We
will return to this point in section 5.1.3.

**Oil-market specific demand shock**

The last row of Figure 5 shows that a much larger, persistent and statistically significant oil trade deficit arises in response to an oil-specific demand shock. In this case as well, major oil importers generate a non-oil trade surplus, consistent with the incomplete markets model, but the response is small and not statistically significant, resulting in a statistically significant overall merchandise trade deficit and (to a lesser extent) current account deficit. Compared with the current account surplus of oil-exporters, not surprisingly, the response is much smaller in magnitude as a share of GDP. There is also evidence of partially statistically significant capital gains in response to oil-specific demand shocks that allow oil importers to run a smaller non-oil trade surplus. These gains mirror in part the capital losses of oil exporting economies, and largely offset the current account deficit. The resulting loss of net foreign assets initially is quite limited as a share of GDP and typically not statistically significant. In years 3 through 5, the capital gains more than offset the current account deficit.

**Aggregate demand shock**

In response to a positive aggregate demand shock, a statistically significant oil trade deficit as well as a largely statistically insignificant non-oil trade surplus arises in oil importing countries. The net effect is a marginally statistically significant merchandise trade deficit and a partially statistically insignificant current account deficit. There also is evidence of partially statistically significant capital gains in oil importing countries (mirroring the capital losses in oil exporting economies). These capital gains cause a persistent accumulation of net foreign assets, although that accumulation is largely statistically insignificant.

### 5.1.3. Implications of the Main Results

Figures 4 and 5 in conjunction provide several insights. First, we consistently find that the trade channel of the transmission of these shocks, as reflected in the non-oil trade balance, plays an important role, suggesting that international financial markets are incomplete, even in the case of the most advanced oil-importing economies. At the same time, the limiting case of financial autarky is clearly at odds with the data. Second, in addition to the trade channel, valuation effects in the form of capital gains and losses (on the initial level of gross foreign assets and liabilities) constitute another important channel of transmission. These two results are not unrelated. The
theoretical analysis of valuation effects in Ghironi et al. (2007) and in Devereux and Sutherland (2008) specifically postulated incomplete markets and its predictions would not apply in a complete markets setting. The fact that our empirical results for the non-oil trade balance are inconsistent with the complete markets hypothesis is reassuring in this context.

Documenting the existence of a valuation channel of the transmission of oil demand and oil supply shocks is important for the policy debate on recent global imbalances. To the extent that part of the external adjustment to these shocks operates through valuation effects, there is less need for short-run domestic macroeconomic adjustments. The role of the valuation effect is best understood by focusing on the capital gain responses of the aggregate of oil exporters. These capital gains by construction are measured with respect to the rest of the world and thus may be interpreted as the mirror image of the valuation effects experienced by the rest of the world. The magnitude of these capital gains and losses reflects the degree of international financial integration. International financial integration plays two important roles in the transmission of oil demand and supply shocks. First, it allows risk sharing between oil exporters and oil importers. Ownership of oil assets by residents of oil-importing countries provides some insurance against oil price increases. In turn, ownership of foreign assets by oil producers provides some insurance against falling oil prices for oil-exporting economies. Thus international portfolio diversification helps cushion the impact of oil demand and oil supply shocks. The extent to which this cushion is effective is evident in Figure 4. Although the magnitude, timing and statistical significance of the responses differs, any shock that raises (lowers) the real price of oil is associated with a capital loss (gain) for oil exporters. Moreover, since the external balance of oil exporters is computed with respect to the rest of the world, we know that by construction there must be valuation effects of the opposite sign in the rest of the world.

In addition, international financial integration affects how the burden of adjustment is distributed across oil-importing economies. The valuation effects of individual oil-importing countries (or more generally of subsets of oil-importing economies as in Figure 5) are more difficult to predict because they depend on the cross-ownership of assets among oil-importing economies and on the relative responses of oil-importing countries’ currencies and asset prices. In the absence of detailed information on international asset positions and a multilateral open economy model of asset flows and exchange rates, there are no testable implications of economic theory for how the burden of adjustment should be distributed across countries. Thus, while often
large and systematic, the estimated valuation effects for the major oil-importing countries are more difficult to interpret. Nevertheless, the capital gains experienced by the major oil importers in Figure 5 in response to positive oil demand shocks are fully consistent with the simple bilateral risk sharing interpretation. In contrast, the response of capital gains to an oil supply disruption is consistent with that interpretation only in years 3 through 5. In the short run, major oil importers experience a capital loss rather than the capital gain suggested by the bilateral model. Since we know from Figure 4 that oil exporters in the aggregate are experiencing a short-run capital loss, the likely explanation is that the simple bilateral framework is too simplistic for predicting the valuation effect on the three major oil importers.

Even when the capital gain responses in Figure 5 have the sign predicted by the bilateral model, as in the case of the other two shocks, the model’s prediction that the capital gains in oil importing countries should be smaller in magnitude than the capital losses in oil exporting countries is not supported by the data. Again, this result is not surprising, as the theoretical model does not incorporate information about the composition of different countries’ portfolios by currency and about the implied multilateral real exchange rate adjustments. Clearly, stylized bilateral models of oil importers and oil exporters are not rich enough to generate reliable predictions for individual countries, even for large economies such as the United States or the Euro area, and economic models of the valuation effect will require further refinement, before these issues can be addressed. We do not pursue this line of reasoning in this paper both because of the difficulty of empirically modeling the response of exchange rates in a multilateral setting and because of the lack of information on cross-country asset holdings. Despite these caveats, the results in Figures 4 and 5 leave no doubt that oil demand and oil supply shocks trigger large and systematic valuation effects.

5.1.4. Differences between the Euro area, Japan, and the United States

Whereas the discussion so far has focused on broad aggregates of oil exporters and oil importers, this subsection highlights some of the differences between major oil importers. We focus on the United States, the Euro area, and Japan.

**Differences in the Dependence on Oil Imports**

One implication of the theoretical analysis in Bodenstein et al. (2007) is that an oil supply disturbance should cause a larger oil trade deficit in countries such as Europe and Japan that are
heavily dependent on imported oil than for the United States which relies to a greater extent on domestic crude oil production to meet its energy needs. Figures 6 confirms that the U.S. oil trade deficit caused by an oil supply disturbance is negligible compared to the deficits in Europe and in Japan. The country most susceptible to oil supply shocks is Japan. The same pattern in the oil trade account is found even more clearly in the responses to oil-specific demand shocks and aggregate demand shocks. Thus, the VAR estimates are consistent with this implication of the Bodenstein et al. model.

5.2. Variance Decompositions
The impulse responses in Figures 4 and 5 illustrate the impact of a one-time demand or supply shock on external balances. A related and equally important question is how important each shock has been on average during our sample period in determining fluctuations in external balances. Table 3 summarizes the results of this variance decomposition for the broad aggregates of oil exporters and oil importers.

Not surprisingly, the combined effect of the three shocks explains almost 96% of the fluctuations in the oil trade balance of oil exporters and almost 89% of their current account fluctuations. Whereas only 66% of capital gains are explained, 82% of the variation in NFA positions of oil exporters is accounted for based on these shocks. For the major oil importers, these shocks also account for 92% of the oil trade balance, but are considerably less important for the non-oil trade balance (47%), trade balance (75%), and current account (57%), reflecting the lesser dependence of these economies on global commodity markets. Nevertheless, the shocks in question account for about 75% of the variation in oil importers’ capital gains and NFA positions.

It is important to keep in mind that these results do not mean that oil price shocks account for 57% of the fluctuations in oil importers’ current account, for example, since the shocks that drive the global price of crude oil may also affect the current account directly. In particular, the aggregate demand shock is best thought of a shock to the global business cycle. It is instructive to decompose the contribution of the three shocks. Table 3 shows that the bulk of the variation in the oil trade balance is driven by oil-market specific shocks (49% and 55%, respectively, for oil exporters and oil importers), followed by aggregate demand shocks (39% and 30%, respectively). Oil supply shocks play a less important role (about 7% in both cases). The relative importance of aggregate demand and oil-specific demand shocks for the variation in both oil
exporters’ and oil importers’ current account is more balanced. The two demand shocks each
account for about a third of the variation in oil exporters’ current accounts, and less than a
quarter of the variation in major oil importers’ current accounts. Their relative importance for
capital gains ranges from 15% to 30%, approximately. Oil supply shocks account for about 22%
of the capital gains and 33% of the changes in NFA in oil importing countries, about the same
order of magnitude as the demand shocks. While these results are necessarily tentative, they
provide a first glimpse at the determinants of these external accounts.

5.3. Historical Decompositions
Since several demand and supply shocks occur at any given point in time, and since the
composition of innovations to the real price of oil evolves over time, impulse response estimates
and variance decompositions do not tell us how much of the evolution of the external accounts
must be attributed to a given shock during specific historical episodes. Historical decompositions
of the fluctuations in external accounts shed light both on the cumulative effect of each oil
demand and supply shock on a given external account and on their combined effect. They can be
constructed by simulating the path of the dependent variable from the fitted regression model (2)
under the counterfactual assumption that a given demand or supply shock in the oil market is
zero throughout the sample. The difference between this counterfactual path of the dependent
variable and its actual path is a measure of the cumulative effect of the shock in question.

5.3.1. The Cumulative Effect of Oil Demand and Supply Shocks on External Accounts
Figures 7a and 7b show the cumulative effect of all three oil shocks combined on external
accounts for oil exporters and for the major oil importers. Although the three shocks explain by
no means all movements in external accounts, they do explain a large part. With the exception of
the non-oil trade deficit (and resulting current account deficit and loss of net foreign assets) in
oil-exporting countries between 1985 and 1993, these shocks explain at least the trend of the
trade and current account data and in many cases the rather abrupt shifts in NFA positions. In
particular, the model explains quite well the growing U.S. current account deficit since 1999 and
most of the fluctuations in the U.S. NFA position. A similarly good fit is obtained for the Euro
area and Japan.

5.3.2. The Evolution of the Relative Importance of Each Shock for the Current Account
Figure 8 decomposes the current account of oil exporters further to highlight the driving forces
behind the large current account fluctuations. This decomposition is of particular interest, since by construction the mirror image of this decomposition is indicative of the evolution of the current account of all oil importers combined as well. Figure 8 shows that much of the oil exporters’ current account surplus since 2003 was driven by a combination of aggregate demand shocks and (to a much lesser extent) oil supply shocks. In contrast, the current account deficit of 1998 was associated with the temporary drop in oil-specific as well as aggregate demand following the Asian crisis of 1997, when oil prices reached an all-time low in recent history. Oil supply shocks played no role. On the other hand, the current account deficit of 1991/92 reflected a combination of all three shocks, working in the same direction.

6. Conclusions

This paper provided the most comprehensive analysis to date of the effects of oil demand and supply shocks on external balances covering a wide range of countries. Our analysis explicitly recognized that oil price changes reflect at least in part the state of the global economy, as illustrated by the surge in the real price of oil since 2004 driven by strong global demand for crude oil. We also distinguished between oil price changes driven by crude oil supply shocks, oil price changes driven by shocks to global aggregate demand for industrial commodities, and oil price changes driven by oil-market specific demand shocks such as shocks to the precautionary demand for oil. This distinction between different types of shocks is crucial. As emphasized in the paper, crude oil-price increases (all else equal) will affect external balances of oil importers differently depending on whether they reflect increased demand for oil or decreased supply of oil. This result is consistent with evidence that these shocks have qualitatively and quantitatively different effects on the real price of oil.

Our study complements recent theoretical advances in modeling the effects of oil demand and oil supply shocks on external balances. This theoretical work has highlighted the importance of empirical studies of how external accounts respond to oil demand and oil supply shocks. For example, economic theory is informative about the direction and overall pattern of the response of the oil trade balance to an oil supply shock, but it is quiet about the magnitude of the response in question. Likewise, depending on the degree of financial market integration, the non-oil trade balance may not respond at all to an oil supply shock or the response could be potentially quite large. In addition, to date there has been no theoretical analysis of global aggregate demand
shocks in industrial commodity markets. The effect of such shocks on external balances tends to be rather complicated, making it difficult to generate any theoretical predictions. These facts make the empirical analysis of the response of external balances all the more relevant.

Our key findings are: (1) Global business cycle demand shocks and oil-specific demand and supply shocks are important for the determination of external balances. For example, they jointly account for 86% of the variation in the current account of an aggregate of oil exporters and for 82% of the corresponding changes in NFA positions (all expressed as a share of GDP). Oil-market specific demand and supply shocks jointly account for about half of the variation in changes in NFA positions, whereas demand shocks associated with the global business cycle account for an additional one third.

(2) In general, the nature of the transmission of oil price shocks is highly dependent on the cause of the oil price increase. For example, positive oil demand shocks are associated with a statistically significant accumulation of NFA in oil exporting economies (and a corresponding decline in the rest of the world), whereas negative oil supply shocks are associated with a statistically insignificant decline in NFA. A second example is that a positive innovation to global aggregate demand causes a current account surplus in oil-exporting economies that peaks in years 2 and 3 after the shock, whereas an oil-market specific demand shock causes a current account surplus in oil exporting economies that peaks immediately in years 0 and 1.

(3) Regardless of the shock, there are systematic differences in the responsiveness of the U.S., European and Japanese oil trade balance to oil demand and oil supply shocks. Of the major oil importers, Japan is the most exposed to such shocks, whereas the United States is the least exposed, reflecting the extent to which these countries rely on imported oil. The overall effect of oil demand and supply shocks on the trade balance of oil importers (and oil exporters) depends critically on the response of the non-oil trade balance. Empirical evidence on the response of the non-oil trade balance is especially useful because theory puts few restrictions on that response. Moreover, the extent to which the non-oil trade balance moves in response to external shocks sheds light in the degree of international financial integration. Our empirical results suggest that neither models of financial autarky nor complete markets model provide a good approximation to the data, and provide a benchmark for the construction of theoretical models of the transmission of oil demand and oil supply shocks under incomplete markets.
(4) In addition to the adjustment of the trade balance and current account, a second channel of adjustment is provided by valuation effects in the form of capital gains or capital losses. We found evidence of systematic valuation effects in response to oil demand and oil supply shocks for both oil exporters and oil importers. International financial integration overall has tended to cushion the effect of oil demand and supply shocks on the change in NFA positions of oil importers and oil exporters. Our results highlight the importance of incorporating trade in assets in theoretical models of oil price shocks and suggest that theoretical models that ignore this channel of transmission will not be consistent with the data. We concluded that in predicting the effects of oil demand and supply shocks on external balances it is necessary to consider not only the degree of an economy’s international financial market integration, but also its external portfolio configuration.

(5) Finally, our results also are of interest for the recent policy debate about growing external imbalances. For example, we showed that the widening imbalance in the U.S. current account can be explained to a large extent by the cumulative effect of the demand shocks reflecting the global business cycle as well oil-market specific demand and supply shocks. More generally, our analysis suggests that shocks to the demand for industrial commodities driven by the global business cycle have played a significant role in recent years in the emergence of external imbalances.

References


## Data Appendix

### A. Variable List

<table>
<thead>
<tr>
<th>Description</th>
<th>Calculation</th>
<th>Units/Scale</th>
<th>Variable Name</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross domestic product, current prices, U.S. dollars</td>
<td></td>
<td>Billions of</td>
<td>gdp</td>
<td>IMF World Economic Outlook</td>
</tr>
<tr>
<td>Net external position</td>
<td></td>
<td>Millions of</td>
<td>nfa</td>
<td>Lane/Milesi-Ferretti</td>
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<tr>
<td>Net foreign assets as a share of GDP</td>
<td>((nfa/1000) / gdp) * 100</td>
<td>Percent of GDP</td>
<td>nfa_gdp</td>
<td>Lane/Milesi-Ferretti, IMF World Economic Outlook</td>
</tr>
<tr>
<td>Current account balance</td>
<td></td>
<td>Billions of</td>
<td>ca</td>
<td>IMF World Economic Outlook</td>
</tr>
<tr>
<td>Current account balance as a share of GDP</td>
<td>((ca /gdp) * 100)</td>
<td>Percent of GDP</td>
<td>ca_gdp</td>
<td>IMF World Economic Outlook</td>
</tr>
<tr>
<td>Trade balance for goods</td>
<td></td>
<td>Billions of</td>
<td>tb</td>
<td>IMF World Economic Outlook</td>
</tr>
<tr>
<td>Trade balance as a share of GDP</td>
<td>((tb /gdp) * 100)</td>
<td>Percent of GDP</td>
<td>tb_gdp</td>
<td>IMF World Economic Outlook</td>
</tr>
<tr>
<td>Oil trade balance</td>
<td></td>
<td>Billions of</td>
<td>tbo</td>
<td>IMF World Economic Outlook</td>
</tr>
<tr>
<td>Oil trade balance as a share of GDP</td>
<td>((tbo/gdpd) * 100)</td>
<td>Percent of GDP</td>
<td>tbo_gdp</td>
<td>IMF World Economic Outlook</td>
</tr>
<tr>
<td>Non-oil trade balance</td>
<td></td>
<td>Billions of</td>
<td>tbno</td>
<td>IMF World Economic Outlook</td>
</tr>
<tr>
<td>Non-oil trade balance as a share of GDP</td>
<td></td>
<td>Percent of GDP</td>
<td>tbno_gdp</td>
<td>IMF World Economic Outlook</td>
</tr>
<tr>
<td>Change in NFA over the previous year</td>
<td>(nfa_t - nfa_{t-1})</td>
<td>Millions of</td>
<td>dnfa</td>
<td>Lane/Milesi-Ferretti</td>
</tr>
<tr>
<td>Change in NFA as a share of GDP</td>
<td>(((dnfa/1000) / gdp) * 100)</td>
<td>Percent of GDP</td>
<td>dnfa_gdp</td>
<td>Lane/Milesi-Ferretti, IMF World Economic Outlook</td>
</tr>
<tr>
<td>Capital gains as defined by the difference between the change in NFA and the current account balance</td>
<td>( (dnfa/1000) - ca)</td>
<td>Billions of</td>
<td>capgain</td>
<td>Lane/Milesi-Ferretti, IMF World Economic Outlook</td>
</tr>
<tr>
<td>Capital gains as a share of GDP defined by the difference between the change in NFA and the current account balance divided by GDP</td>
<td>((capgain/gdp) * 100)</td>
<td>Percent of GDP</td>
<td>capgain_gdp</td>
<td>Lane/Milesi-Ferretti, IMF World Economic Outlook</td>
</tr>
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</table>

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Table 1: Correlations of Demand and Supply Shocks in Crude Oil Market Aggregated to Annual Frequency 1975-2006

<table>
<thead>
<tr>
<th></th>
<th>Oil Supply Shock</th>
<th>Aggregate Demand Shock</th>
<th>Oil-Specific Demand Shock</th>
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</thead>
<tbody>
<tr>
<td>Oil Supply Shock</td>
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<td>0.05</td>
<td>-0.11</td>
</tr>
<tr>
<td>Aggregate Demand Shock</td>
<td>-</td>
<td>1</td>
<td>-0.07</td>
</tr>
<tr>
<td>Oil-Specific Demand Shock</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
</tbody>
</table>

NOTES: The oil shocks are obtained from model (1) as described in the text.

Table 2: Correlations of the Innovations of External Balances (as a Percent Share of GDP) with Oil Shocks United States

<table>
<thead>
<tr>
<th>Share in GDP</th>
<th>Oil Supply</th>
<th>Aggregate Demand</th>
<th>Oil-Specific Demand</th>
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<tbody>
<tr>
<td>Change in NFA</td>
<td>-0.03</td>
<td>0.11</td>
<td>0.02</td>
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<td>Current Account</td>
<td>-0.04</td>
<td>0.04</td>
<td>-0.14</td>
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<tr>
<td>Trade Balance</td>
<td>0.00</td>
<td>0.07</td>
<td>-0.26</td>
</tr>
<tr>
<td>Oil Trade Balance</td>
<td>0.27</td>
<td>-0.22</td>
<td>-0.58</td>
</tr>
<tr>
<td>Non-Oil Trade Balance</td>
<td>-0.11</td>
<td>0.17</td>
<td>0.14</td>
</tr>
<tr>
<td>Capital Gain</td>
<td>-0.16</td>
<td>0.20</td>
<td>-0.07</td>
</tr>
</tbody>
</table>

NOTES: The innovations are estimated as the residuals of AR(4) models for each of the external balance measures. The oil shocks are obtained from model (1) as described in the text. Qualitatively similar results are obtained with other lag orders.
<table>
<thead>
<tr>
<th>External Account</th>
<th>Oil Supply Shock</th>
<th>Aggregate Demand Shock</th>
<th>Oil-Specific Demand Shock</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil Exporters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil Trade</td>
<td>7.2</td>
<td>39.3</td>
<td>49.4</td>
<td>95.9</td>
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<tr>
<td>Non-Oil Trade</td>
<td>23.7</td>
<td>20.4</td>
<td>29.1</td>
<td>73.2</td>
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<td>Trade</td>
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<td>35.2</td>
<td>44.4</td>
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<td>12.0</td>
<td>34.4</td>
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<td>85.7</td>
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<td>15.8</td>
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<td>Change in NFA</td>
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<td>Oil Importers</td>
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<td>Oil Trade</td>
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<td>29.8</td>
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<td>92.1</td>
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<tr>
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<td>Current Account</td>
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<td>76.8</td>
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<tr>
<td>Change in NFA</td>
<td>32.8</td>
<td>16.9</td>
<td>25.0</td>
<td>74.8</td>
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</tbody>
</table>

NOTES: All results are based on the $R^2$ estimates implied by model (2), suitably scaled to match the total $R^2$ from an analogous regression of the dependent variable on current and lagged values of all three shocks.
Figure 1: Responses to One-Standard Deviation Structural Shocks
OLS Point Estimates with One- and Two-Standard Error Bands

NOTES: Estimates based on restricted VAR(24) system described in text. The confidence intervals were constructed using a recursive-design wild bootstrap (see Gonçalves and Kilian 2004).
Figure 2: Historical Decomposition of Real Price of Oil 1976.1-2006.12

NOTES: See Figure 1.
Figure 3: Annual Averages of the Shocks that Determine the Real Price of Oil
Estimates for 1975-2006

NOTES: Annual averages of the structural shocks underlying the responses in Figure 1.
Figure 4: Responses of External Accounts as a Share of GDP with One-Standard Error Bands
Aggregate of Oil Exporters

NOTES: Estimates based on model described in text. The confidence intervals were constructed using a block bootstrap.
Figure 5: Responses of External Accounts as a Share of GDP with One-Standard Error Bands
Aggregate of Oil Importers

NOTES: See Figure 4.
Figure 6: Responses of Oil Trade Balance as a Share of GDP by Shock with One-Standard Error Bands
United States, Euro Area and Japan

NOTES: See Figure 4.
Figure 7a: Historical Decompositions of Selected External Accounts as a Share of GDP

NOTES: Fitted values of model described in text plotted against demeaned actual data.
Figure 7b: Historical Decompositions of Selected External Accounts as a Share of GDP

NOTES: See Figure 7a.
Figure 8: Historical Decompositions of Oil Exporters’ Current Account as a Share of GDP by Shock

NOTES: See Figure 7a.