Oil Shocks, External Adjustment, and Country Portfolio*

Liugang Sheng Hongyan Zhao

April 17, 2021

Abstract

This study examines the intertemporal nature of countries' external adjustment by using two types of oil income shocks with different timings, namely, giant oil discovery news shocks and contemporaneous oil windfalls arising from the possible exogenous changes in the international oil spot price. Empirical estimates based on a large panel of countries from 1970 to 2011 are consistent with the intertemporal model. Net foreign assets hike immediately upon oil revenue shocks, but decrease in the first five years after oil discoveries, and then increase sharply after oil production starts. Meanwhile, the external adjustments upon oil shocks are largely through the current account channel, and valuation effects only partially stabilize the current account adjustment for oil revenue shocks. Moreover, oil discoveries attract a large amount of foreign direct investment inflow to share the risk of oil extraction, and oil revenue shocks significantly increase the net holdings in low-risk foreign debt assets. Our results indicate that risk-sharing may play an important role in country portfolio diversification.

Keywords: News shocks, external balance, current account, valuation effects, country portfolio, oil discovery

JEL Classification: E00, F30, G15

---

* Liugang Sheng, The Department of Economics, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong. Contact e-mail: lsheng@cuhk.edu.hk. Hongyan Zhao, the Center for Macro Financial Stability and Innovations, Shenzhen Finance Institute, The Chinese University of Hong Kong, Shen Zhen. We thank participants at various seminars and conferences for helpful comments. In particular, we thank Rabah Arezki, Feng Dong, Ling Feng, Pierre-Olivier Gourinchas, Jiandong Ju, Zhiyuan Li, Shu Lin, Zheng Liu, Valerie A. Ramey, Kang Shi, Zheng (Michael) Song, Jian Wang, Pengfei Wang, Shangjin Wei, Xi Weng, Wen Yao, Haichun Ye, Changhua Yu, and Hao Zhou for their insightful comments and discussions.

I. INTRODUCTION

What determines the dynamic evolution of a country's external borrowing and lending? Theoretical advances in the last three decades have provided fundamental insights into this question. The intertemporal theory, inspired by the permanent income hypothesis, characterizes external balance as the intertemporal smoothing mechanism through saving and investment (e.g., Obstfeld and Rogoff, 1995, 1996). The theory predicts that countries should run an external surplus upon positive contemporaneous temporary income shocks, whereas experience external deficits when expecting an increase in future income (Uribe and Schmitt–Grohé, 2017). The underscoring in the timing of shocks marks the key difference between the modern intertemporal theory and the traditional static models of external balance. However, surprisingly it has not yet received systematic empirical examinations on how the timing of shocks matters for countries' external adjustment.[1]

This study aims to fill in this gap by using two types of country-specific oil income shocks with different timings, namely, giant oil discovery news shocks and contemporaneous oil windfalls from possible exogenous changes in the international oil spot price.[2] Giant oil discoveries represent news about high future oil output due to the natural production lag (Arezki, Ramey, and Sheng, 2017, hereafter ARS (2017)), and oil windfalls due to oil spot price changes usually indicate the country's contemporaneous oil income shocks, depending on its dependence on oil and gas. The oil revenue shock has been widely used in the literature as an exogenous source of income shock to study its effect on the countries' external balance, political outcomes, health expenditure, and population growth.[3] The unique feature of differences in timing between two oil shocks offers a great opportunity to study whether the timing of shocks matters for countries' external adjustment in net foreign assets (NFA), the current account, and country portfolio.

[1] The timing of shocks has recently become one of the central focuses of macroeconomic studies. For example, Beaudry and Portier (2006) revived the literature of news-driven business cycles by providing evidence that news regarding future productivity shocks may account for half of the business cycle fluctuations in the U.S. A number of studies examining the government spending or tax policy emphasize that the timings of policy shocks are crucial for identifying government spending or tax multipliers (Ramey, 2011; Barro and Redlick, 2011; Mertens and Ravn, 2012).

[2] A giant oil or gas discovery is defined as the discovery of an oil and/or gas field that contains at least 500 million barrels of ultimately recoverable oil equivalents. Hereafter, we refer to the discoveries of giant oil (including condensate) and gas fields as simply "giant oil discoveries."

[3] Examples include Arezki and Brückner (2012), Brückner, Ciccone, and Tesei (2012), Caselli and Tesei (2016), Acemoglu, Finkelstein, and Notowidigdo (2013), and Brückner and Schwandt (2015).

In the empirical analysis, we use the country-specific risk-adjusted net present value (NPV) of giant oil discoveries from ARS (2017) as the baseline measure of oil discovery news shocks. We also extend their sample of giant oil discovery by including additional 120 discoveries in the 1960s. We construct contemporaneous oil revenue shocks by using the changes in the international oil spot price, which are arguably exogenous to individual country's economic conditions and political outcomes. Many studies have shown that oil price typically follows a unit root process (e.g., Brückner, Ciccone, and Tesei, 2012; Maslyuk and Smyth, 2008), and forecasting oil price is very difficult (e.g., Hamilton, 2009; Baumeister and Kilian, 2016). Thus, the oil revenue shocks from changes in the oil price are largely unexpected. We obtain the country-specific contemporaneous oil revenue shocks by multiplying the change in international oil spot price with the countries' lagged GDP share of net exports of oil and gas.

We focus on the two types of oil shocks also because they are substantial country-specific temporary income shocks to many countries in the world. Giant oil discoveries represent a considerable amount of oil revenue for a typical country of modest size. For our sample, the median value of the constructed NPV as a percentage of a country's GDP is approximately 8.8%. Oil revenue shocks from oil price changes are also important driving forces for external balance in many oil exporters and importers. For example, the net imports of oil and petroleum products contribute roughly one-third of the large current account deficits in the U.S. before the recent shale revolution.[4] Moreover, oil discovery news shocks and oil revenue shocks are temporary because the oil reserve for an individual field is exhaustible and the changes in the oil price are transitory evident by simple autoregressive regressions. Thus, these oil shocks provide unique sources of macro-relevant time-sensitive shocks because finding other direct measures of shocks at the country level with similar significance but different timings is difficult.

To estimate the dynamic impacts of the two types of oil shocks on external balance, we adopt a dynamic panel distributed lag model over a sample covering approximately 180 countries

[4] The oil crises during 1973 to 1974 and 1979 to 1980 resulted in sharp increases in international oil prices and substantial current account imbalances between advanced and developing economies, thereby introducing the intertemporal approach to the current account (e.g., Sachs, 1981; Obstfeld, 1982; Svensson, 1984). Since then, oil price shocks and their consequences on the external balance of countries have been constantly studied in international macroeconomics (Barsky and Kilian 2004; Kilian, 2009). Kilian, Rebucci, and Spatafora (2009) also found that contemporaneous oil market shocks could account for roughly half of the total variations in changes in net foreign assets for oil exporters and major oil importers.

from 1970 to 2011. Panel techniques include year- and country-fixed effects that control for global common shocks and cross-country differences in time-invariant factors, such as a country's geographical location, institutions, and culture. Simultaneously including the contemporaneous oil revenue and discovery news shocks (with lags) in one regression is crucial given that they may be correlated with each other.[5] In particular, oil discoveries may predict future oil revenues, and oil revenue shocks may provide incentives for oil explorations.

The empirical findings provide support to the intertemporal theory of external adjustment. The estimated impulse responses for the two oil shocks show that the timing of shocks plays a key role in the dynamic adjustment of NFA. NFA decreases significantly in the years immediately following an oil discovery with an expectation of high future income and starts to increase around the fifth year as oil production starts. It peaks in the ninth year, and then the effect of the giant oil discovery gradually declines. On the contrary, NFA increases dramatically in the first two years when a country receives positive oil revenue shocks. However, this positive effect decreases rapidly to a negligible level in the ensuing years. The impulse responses of NFA are consistent with the intertemporal model, which predicts that a country should save upon contemporaneous and temporary positive income shocks, but borrow from abroad when expecting high future income.

We further study the channels of external adjustment upon oil shocks. In theory, the external balance of a country can be adjusted either through the current account or valuation effects. Recent studies have shown that the size of the valuation effect increases with rapid global financial integration, and thereby may dwarf the role of the current account in intertemporal adjustment (Lane and Milesi–Ferretti, 2001, 2007; Gourinchas and Rey, 2007). Thus, we also estimate the effects of the two oil shocks on the current account and valuation effects. We find that the dynamic effects of the two oil shocks on the current account are similar to the effects on the changes in NFA, indicating that external adjustment upon oil shocks is largely driven by the current account channel. Valuation effects do not respond to oil discovery shocks significantly, but partially offset the positive effects of oil revenue shocks on the current account.

[5] In the literature of government multipliers, including contemporaneous shocks and news shocks of government spending or tax changes in the same regression is crucial in identifying their effects separately (Barro and Redlick, 2011; Mertens and Ravn, 2012).

We further explore how a country adjusts its country portfolio in response to oil shocks. In particular, we focus on how the country finances its external deficits upon oil discovery shocks and how it manages its portfolio from oil windfalls. Thus, we examine the dynamic effects of the two oil shocks on country portfolio adjustment among foreign direct investment (FDI), debt assets (fixed income assets), and equity assets because they are three dominant financial instruments in the current world financial market.

As a result, we find that after oil discovery, FDI inflow increases significantly due to the boom in oil investment and its spillover on the demands of other sectors, thereby providing funds for current account deficits. The net holding of foreign debt assets declines slightly in the short term, indicating that countries do not rely heavily on the international debt market for external financing. However, the net holding in foreign debt assets increases significantly after the start of oil production or positive oil revenue shocks because the country saves the part of its oil windfalls to hedge the risk of future domestic production by holding more foreign debt assets. We do not find a significant adjustment in foreign equity assets partly due to the low share of foreign equity assets in country portfolio before 1990. In summary, our results suggest that oil-producing economies hedge the risk of oil production by financing through FDI and saving in foreign debt assets because the output of these countries is relatively more volatile than those of other countries. Thus, our findings are largely consistent with the international portfolio diversification theory (Devereux and Sutherland, 2009; Tille and van Wincoop, 2010).

Our baseline results are robust to a wide array of checks. First, we discuss three important underlying assumptions for our identification, namely, the degree of financial openness, the predictability of oil shocks, and the exogeneity of oil price changes. The baseline results are insensitive to external financial frictions given that impulse responses to two oil shocks for financially open or closed economies do not show significant differences except for the valuation effects upon oil revenue shocks, which are remarkable in financially open economies but not in financially closed economies. To address the issue of predictability of two oil shocks, we selectively use discoveries that occurred when no discoveries occurred in the last three years because discoveries that follow others are likely to be criticized as predictable. Meanwhile, we use the residual from of the AR(3) panel model of oil revenue shocks with additional control for discoveries in the past 10 years as the measure of unanticipated oil revenue shocks. All results are virtually unchanged. To ease the concerns of endogeneity of changes in oil price, we remove the top 10 largest oil producers and consumers, or OPEC member countries, or the countries in Middle Eastern and North African that may exert influences on international oil price, and the pattern of the dynamic effects of two oil shocks does not change.

Second, we include additional variables to control for possible confounding factors. For example, we include the log GDP per capita, GDP growth rate, and inflation rate to capture the countries' development level and their business cycle. Moreover, as oil price changes may affect external balance through terms of trade, we also include the changes of terms of trade and official exchange rates in regressions.

Third, our results are robust to alternative measures of oil shocks and alternative samples of countries. These alternative measures include the use of a discovery event dummy and the construction of oil revenue shocks based on total exports or production of oil and gas or average net exports during the sample period or in the past three years. Moreover, we examine the sample of oil exporters only or countries with at least one giant oil discovery, and the baseline results remain to hold. Our results also remain robust when using different model specifications including country-specific linear trends, high-order lags for the dependent variables, and different orders of lags for the two oil shocks. Lastly, we adopt Jordà's (2005) local projections method to estimate impulse responses directly. This alternative econometric method is more robust to heterogeneous slopes and imposes less dynamic restrictions. We find that the estimated impulse responses mostly demonstrate similar patterns as the baseline model for the relevant horizons.

This study makes several empirical contributions to the international macro literature on external adjustment and country portfolio. The intertemporal approach represents a giant leap forward for the theory of external adjustment. However, empirical evidence has yielded mixed results based on the present value model test (PVM), which was originally developed for testing the permanent income hypothesis (Obstfeld and Rogoff, 1995; Gourinchas and Rey, 2014).[6] Thus,

[6] Using the PVM test, Sheffrin and Woo (1990) found that the intertemporal model of the current account performs reasonably well for Belgium and Denmark but fails for Canada and the United Kingdom. Otto (1992), Ghosh and Ostry (1995), and Bergin and Sheffrin (2000) also obtained similar mixed results. Nason and Rogers (2006) and Corsetti and Konstantinou (2012) provided more discussions on the possible reasons for the failure of PVM test. Subsequent studies have attempted to provide explanations for the failure of the intertemporal approach. For example, Ju, Shi, and Wei (2014) showed that the intertemporal adjustment of the current account depends on the country's labor market frictions that affect the intratemporal trade.

the most important contribution of this study is to provide empirical support to the intertemporal theory by directly comparing the impulse responses of changes in NFA and the current account upon two oil income shocks with different timings. Our approach is different from the standard present value tests, which may be subject to debate because they rely on many untested assumptions on the model setup and VAR specification (Nason and Rogers, 2006). Our approach is closer to the quasi-natural experiment analysis, which does not rely on identification assumptions using VAR or parametric dynamic stochastic general equilibrium (DSGE) models.

Our study also sheds light on the ongoing heated debate on the relative importance of the current account and valuation effects for external adjustment. Gourinchas and Rey (2007) underscore the importance of the valuation effects by showing that the returns of U.S. holdings in foreign assets are higher than foreigners' returns from their holdings in U.S. assets, and this valuation effect partially offsets the large current account deficits of the U.S. in recent decades (Corsetti and Konstantinou, 2012; Evans, 2014).[7] However, recent studies have shown that the return premia of U.S. investors are substantially lower than previous estimates, and thus the valuation effects might be less substantial for intertemporal substitution.[8] The theoretical and empirical works on the relative importance of the current account and valuation effect channels are in flux, and the debate also extends to the policy circles (Bernanke, 2005; Obstfeld, 2012).[9] Our study contributes to this ongoing debate by showing that the changes in NFA upon oil shocks are largely through the current account channel, and the valuation effects only stabilize the current account adjustment in the short run for oil revenue shocks in financially open economies. Thus,

[7] Corsetti and Konstantinou (2012) found that changes in NFA have a predictive power for future net output and excess return of NFA using the U.S. time series data. Evans (2014) also showed that the valuation effect is more important than the trade channel for the U.S.

[8] Refer to Curcuru, Dvorak, and Warnock (2008), Curcuru, Thomas, and Warnock (2013), and McGrattan, Prescott (2010). Theoretically, Devereux and Sutherland (2010) and Pavlova and Rigobon (2010) also found the difficulty in generating large anticipated capital gains within a reasonably calibrated open macro model with portfolio choice.

[9] In the Richard T. Ely lecture at the annual meeting of American Economic Association in 2012, Maurice Obstfeld criticized the view that current account is no longer important and elaborated on the importance of the macroeconomic implications of the current account imbalance. He also pointed out that the valuation channel is less important than the current account channel in many countries other than the U.S. (Obstfeld, 2012).

our results largely support the view of Obstfeld (2012) that the current account adjustment remains an important channel for external adjustment.[10]

This study also contributes to the growing international macro-finance literature that incorporates portfolio choice and capital flows into the models of open economy macroeconomics. The influential work of Gourinchas and Rey (2007) and the debate on valuation effects have reignited interests in country portfolio choice in standard open macroeconomic models. Although theoretical modeling has achieved remarkable progress in integrating the country portfolio choice into standard DSGE models, empirical studies on country portfolios are limited.[11] Our study shows that country portfolio adjustments upon two oil shocks are remarkably different, and risk-sharing may be an important factor for country portfolio choice. Thus, our analysis presents interesting empirical facts to the literature and may be useful for future development of open macroeconomic models (Tille and van Wincoop, 2010; Devereux and Sutherland, 2011; Pavlova and Rigobon, 2015).

Lastly, this study is also related to another broad literature on the macroeconomic effects of oil shocks for oil importers and exporters, particularly on the external balance (Bruno and Sachs, 1982; Rebucci and Spatafora, 2006; Bodenstein, Erceg, Guerrieri, 2011, and Kilian, Rebucci, and Spatafora, 2009).[12] Most existing studies focus on the effects of contemporaneous oil price shocks on major oil importers and exporters, whereas this study emphasizes the importance of the timing difference between oil news shocks and contemporaneous oil revenue shocks and their differential dynamic effects on the external adjustment and international portfolio.

---

[10] Our results should not be interpreted against Gourinchas and Rey (2007) because they examine the role of valuation effects in the external adjustment for the U.S. However, we focus on the effects of oil shocks for cross-country panel analysis.

[11] For example, Tille and van Wincoop (2010), Devereux and Sutherland (2011), and Evans (2014) developed solutions to portfolio choice in a class of two-country DSGE models using higher-order approximation methods. Pavlova and Rigobon (2010, 2015) and Heathcote and Perri (2013) developed closed-form solutions to the country portfolio in incomplete and complete market settings.

[12] Barsky and Kilian (2004) conducted a comprehensive review of a series of important questions about the macroeconomic effects of oil price shocks since 1970. The seminal study of Kilian (2009) identified the underlying global supply and demand determinants of oil price shocks, and Kilian, Rebucci, and Spatafora (2009) further showed the effects of global supply and demand shocks on the external balance for two groups of major oil importers and exporters. Our study is complementary to theirs, but our identification method is very different. Their method relies on the time series variations in the *global* supply and demand shocks in oil price, while we use two types of *country-specific* oil income shocks and adopt the dynamic panel regression approach. More importantly, we emphasize the key difference in timing for two types of oil shocks, leading to sharply different responses in the country's external adjustment.

The remainder of the paper is organized as follows. Section II discusses the measurement of oil shocks and external balance. The empirical strategy is laid out and illustrated in Section III, and the main results for external balance are presented in Section IV. The empirical results for the country portfolio are shown in Section V. Additional discussion on our underlying identification assumptions are provided in Section VI, and a discussion of the robustness checks is given in Section VII. Section VIII concludes with some remarks.

II. OIL SHOCKS AND EXTERNAL ADJUSTMENT

II.A. Theoretical Background

What determines the dynamics of the external deficit or surplus in a country? Early static models, such as the "elasticity approach," either emphasize the relative price elasticities of the supply and demand of international trade or stress the difference between the domestic aggregate demand and output in accordance with the "absorption approach." On the contrary, intertemporal models consider external adjustment as the outcome of intertemporal decisions of consumption, saving, and investment. Thus, temporary news shocks and contemporaneous shocks have very different implications for external adjustment. Countries should run an external surplus upon positive *contemporaneous* temporary income shocks but experience external deficits when expecting an increase in *future* income (e.g., Sachs, 1981; Obstfeld, 1982; Svensson, 1984). The underscoring in the timing of shocks marks the key difference between the modern intertemporal theory and the traditional static models of external balance. However, surprisingly it has received little empirical examinations in the literature. Thus, we aim to fill in this gap by using two oil income shocks with different timing.

II.B. Our Empirical Approach

We adopt a novel quasi-natural experiment approach to explore the key insights from the intertemporal model by using two types of oil shocks that represent *temporary country-specific* income shocks with sharply different timings: Worldwide giant oil discoveries news shocks and contemporaneous oil revenue shocks due to possible exogenous changes in the international oil price. The baseline intertemporal model predicts that the country should run external deficits upon oil discovery news shocks but experiences external surplus upon contemporaneous temporary oil revenue shocks. Thus, the unique feature of timing between the two oil shocks offers an invaluable opportunity to examine the intertemporal theory of external adjustment and to further evaluate the relative importance of the trade and valuation channels.

Subsequently, we discuss how we construct two types of oil shocks in detail. The first oil shock is the worldwide giant oil and gas discoveries as news shocks regarding high future income from ARS (2017). ARS (2017) showed that giant oil discoveries are an ideal measure of country-specific news about future output because they have an average natural production lag of four to six years and are relatively large in terms of the ultimate recoverable reserves, and the timing of oil discoveries is plausibly exogenous. [13] Moreover, oil resources are exhaustible, and the reserve of one particular field is depleted rapidly after production starts. Thus, oil discoveries are *temporary country-specific* news shocks. We use the NPV of oil discoveries adjusted by the country-specific interest rate from ARS (2017) as the baseline measure of news shocks, which is defined as follows:

$$NPV_{i,t} = \frac{\sum_{j=5}^{J} \frac{q_{i,t+j} * oilprice_t}{(1+r_i)^j}}{GDP_{i,t}} \times 100 \qquad (1)$$

The *NPV* for a given country, *i*, at the time the discovery is made, *t*, is the discounted sum of gross revenue derived from an approximated oil production profile, $q_{i,t+j}$, from the fifth year following the discovery to the exhaustion year, J, valued at the oil price prevailing at the time of the discovery. The approximated production profile follows a piecewise process in the form of a reserve-specific plateau production followed by an exponential decline.[14] We extend the sample of ARS (2017) for oil discoveries from 1970 to 2011 by including 120 discoveries in the 1960s, the peak of giant oil discoveries since 1960. Thus, the total number of giant oil discoveries increases from 371 in ARS (2017) to 491 in this study. Table I presents the spatial and temporal distribution of giant oil

[13] The focus of the present study is different from that of ARS (2017) that explored the effects of oil discoveries on macro variables, such as output, current account, and employment. On the contrary, we focus on the effects of the two types of oil shocks on external adjustment, relative importance of current account and valuation effects, and country portfolio dynamics.

[14] ARS (2017) Appendix B.I. provides the detailed construction method for the production profile of oil discovery.

discoveries from 1960 to 2011 as recorded by Horn and Myron (2014).[15] Our constructed NPV of oil discoveries, as the measure of oil news shock, may involve measurement errors due to various technical reasons. Thus, as an alternative, we use the discovery dummy variable as the measure of oil news shock in the robustness check.

We construct the contemporaneous country-specific oil income shocks by using the possible exogenous changes in international oil price.[16] Many studies have shown that the international oil price typically follows a unit root process (e.g., Brückner, Ciccone, and Tesei, 2012; Maslyuk and Smyth, 2008). The augmented Dickey-Fuller test does not reject the hypothesis of a unit root in the logarithm of the international oil price. The Lee and Strazicich (2003) test, which allows for one or two structural breaks in the mean and the trend of oil price levels, also fails to reject the hypothesis of a unit root in the oil price at the 10% significance level (but rejects the hypothesis of a unit root in the first differenced oil price at the 1% significance level). Therefore, we proceed under the assumption that there is a unit root in international oil price but the changes in oil prices are stationary.

Moreover, we find that lagged values of oil price changes do not have predictive power for the current oil price change. For example, the coefficients of lagged values of oil price changes are all close to zero and insignificant when we use an AR(3) model for oil price changes. This finding is consistent with fact that forecasting oil price and its change is difficult because predicting the determinants of the oil price (from the demand and supply sides) can be very difficult in practice, although we have a better understanding of the causes of the oil price fluctuations in the last four decades (Hamilton, 2009; Baumeister and Kilian, 2016). Thus, the changes in the oil price over time correspond to unanticipated oil price shocks.

[15] The distribution of the logarithm of the size of giant oil discoveries measured in million barrels of ultimately recoverable oil equivalent is similar to Figure V of ARS (2017).

[16] Previous studies have constructed the contemporaneous oil windfalls arising from the changes in international oil price. For example, Brückner, Ciccone, and Tesei (2012) and Caselli and Tesei (2016) used the oil windfalls from oil price changes to study the effects of oil income on political outcomes, such as democracy and political stability. Acemoglu, Finkelstein, and Notowidigdo (2013) and Brückner and Schwandt (2015) use oil price shocks to study the effects of income on health expenditure and population growth, respectively. The common assumption for this identification assumption is that changes in international oil prices are largely exogenous to individual country's economic conditions and political outcomes.

To construct the county-specific oil revenue shocks from oil price changes, following Brückner, Ciccone, and Tesei (2012) and others, we multiply the country's lagged GDP share of net exports of oil and gas with the changes in international oil price as follows: [17]

$$Oilrevshk_{it} = \frac{Net\ exports\ of\ oil\ and\ gas_{i,t-1}}{GDP_{i,t-1}} * \frac{\Delta Oil\ Price_t}{Oil\ Price_{t-1}} * 100.$$

Thus, $Oilrevshk_{it}$ largely measures unanticipated oil windfalls due to international oil price shocks for those countries.[18] We also conduct a panel unit root test that rejects the unit root hypothesis at standard significance levels, indicating that oil revenue shocks are temporary shocks. We use the GDP share of net exports of oil and gas as the weights because it is more closely related to the country's external balance. Alternatively, we also use the lagged GDP shares of gross exports or production of oil and gas as the weights to construct oil revenue shocks for robustness checks.

One advantage of our measure of oil revenue shocks based on net exports of oil is that it uses variations from oil exporters and oil importers, given the fact that negative shocks to oil price are positive income shocks for oil importers. Thus, our sample covers most countries given the data availability, and our results are more robust because they do not depend on the sample selection of countries. However, one caveat of this measure is that oil price shocks are not only income shocks but also have relative price effects. The income effects of oil price shocks may be dominant for oil exporters but the relative price effects might be important for oil importers. In the robustness check, we include terms of trade to control the relative price effects and use an alternative sample of oil exporters only; we find that this concern is not crucial. Thus, we include oil exporters and importers in the baseline specification.

[17] We prefer the time-varying lagged GDP shares of net exports of oil and gas as the weight because this measure is more accurate in capturing the magnitude of oil price shocks on countries' oil revenue than others using fixed weights, such as country's average or initial GDP shares of net exports of oil and gas. Using the fixed weights may lead to nontrivial measurement errors and estimation bias. The issue of measurement error is more complicated in the dynamic panel setting than the classic one in static linear models (Lee, Hyungsik and Zhou, 2017). For robustness checks, we adopt different weights including the country's average GDP share of net exports of oil and gas during the sample period or in the past three years.

[18] Alternatively, we can use the log difference in oil price, and the estimation results are similar. We prefer percentage change in oil price because it is relatively easy for quantitative interpretation of the oil revenue shocks in subsequent analysis.

One may have additional concerns on our construction methods of two oil income shocks, such as the predictability of those shocks and the exogeneity of oil price shocks. To address those concerns, we conduct extensive sensitivity analysis, such as using various alternative measures of oil revenue shocks and excluding countries that may have market power in influencing the international oil price. We discuss these issues extensively in the following section.

The trade data of oil and gas between 1960 and 2011 are retrieved from the World Integrated Trade Solution, and the production data are retrieved from the Ross–Mahdavi Oil and Gas dataset, which is widely used in the literature (Lei and Michaels, 2014). The data on external balance and its portfolio composition are from the updated and extended version of the dataset constructed by Lane and Milesi–Ferretti (2007). The updated version reports the current account, GDP, aggregate foreign assets and liabilities, and the breakdown between direct investment, debt, and others (including equity) for more than 180 countries from 1970 to 2011. GDP and oil price data are from the IMF World Economic Outlook database. Following the literature (e.g., Gourinchas and Rey, 2007; Devereux and Sutherland, 2010), the valuation effect is measured as the difference between the change in the NFA and the current account.[19] The summary statistics of the NFA, the current account, valuation effects, the compositions of the international portfolio, and the two oil shocks are presented in Table II.

III. EMPIRICAL SPECIFICATION

Following ARS (2017), we adopt a dynamic panel model with distributed lags to examine the effects of the two types of oil shocks on the external balance and country portfolio, as follows:

$$y_{it} = A(L)y_{it} + B(L)Disc_{it} + C(L)Oilrevshk_{it} + \alpha_i + \mu_t + \gamma' Z_{it} + \epsilon_{it}, \qquad (2)$$

where y_{it} represents the dependent macroeconomic variables expressed as a percentage of GDP, including changes in net foreign assets, the current account, valuation effects, and changes in net assets of FDI, foreign debts, and foreign equity. Changes in the total assets and liability positions as percentages of GDP for each portfolio instrument are also available. $Disc_{it}$ is the NPV of giant oil discoveries as a percentage of GDP from ARS (2017), and $Oilrevshk_{it}$ is the net oil and gas

[19] Empirically, the changes in NFA also include the statistical discrepancy of the balance of payment. Given the data limitation, we are unable to identify the statistical discrepancy. More discussions on this issue are presented in Lane and Milesi–Ferretti (2001, 2007).

export revenue shocks as a percentage of GDP. α_i controls for country-fixed effects, which capture the unobserved time-invariant characteristics, such as geographical location. μ_t refers to the year effects controlling common shocks, such as global business cycles and international crude oil and gas prices. Z_{it} represents other control variables, such as other macroeconomic variables that may affect external adjustment and country-specific linear trends used in robustness exercises. ϵ_{it} is the disturbance. $A(L)$ is the pth order, and $B(L)$ and $C(L)$ are the qth order lag operators with $p \geq 1$ and $q \geq 0$, respectively. The benchmark regression setting uses $p = 1$ and $q = 10$.

The panel structure allows the identification of the dynamic effects of the two types of oil shocks on external balance and country portfolio while controlling for the country- and year-fixed effects. Controlling for country-fixed effects is important because it allows the estimation of the effects of the within-country variations in oil discovery shocks and oil revenue shocks on within-country variations in the external balance and country portfolio, thereby controlling for any unobservable and time-invariant characteristics that may lead to an omitted variable bias.[20] The dynamic feature of the panel regression in the form of an autoregressive model with distributed lags allows the computation of the impulse response functions (IRF) to capture the dynamic effects of the two types of oil shocks, which are given by $B(L)/(1 - A(L))$ and $C(L)/(1 - A(L))$ respectively.

Simultaneously including contemporaneous oil revenue and discovery news shocks in one regression is important because the two types of shocks may be correlated with each other. In particular, oil discovery may predict future oil revenue, and oil revenue shocks may provide incentives for oil explorations. Lei and Michaels (2014) found that oil production and oil exports increase by approximately 35% to 50% and 20% to 50%, respectively, within four years or six years to 10 years after a giant oil discovery. Thus, the regression that includes oil revenue shocks only may have omitted variable bias. On the contrary, Equation (2) implies that the estimated IRF $C(L)/(1 - A(L))$ measures the effect of a one-unit increase in current oil revenue shocks for the given values of the other right-side variables, including giant oil discoveries and oil revenue shocks

[20] The estimates of the dynamic panel with fixed effects are inconsistent if the time span of the panel (T) is small. In this study, the sample period covers approximately 40 years, approximately 10 years longer than the sample period in ARS (2017). Thus, the Nickell bias of order (1/T) may be negligible.

in the past 10 years. The same statement holds for the computed IRF $B(L)/(1 - A(L))$ for the NPV of discovery news.

Our sample in the baseline specification covers approximately 180 countries including oil exporters and importers, depending on the data availability of each variable of interest. The large coverage of countries in the sample utilizes variations both from oil exporters and importers and allows us to experiment with various subsamples for robustness checks. The regression covers the period 1970–2011 given that most of the dependent variables on external wealth are only available since 1970. However, the oil discovery shocks and oil revenue shocks in the 1960s are also included in the regression given that we use long lagged independent variables.

IV. BENCHMARK RESULTS ON EXTERNAL BALANCE

We present the benchmark results for the dynamic effects of oil discovery shocks and oil revenue shocks on external balance. The dynamic responses to two oil shocks are shown in two columns in Figures I and II. The left column shows the effects of an oil discovery news shock, and the right column presents the impact of contemporaneous oil revenue shocks. The shaded areas are 90% and 68% (dark gray) confidence bands calculated using Driscoll–Kraay (1998) standard errors and the delta method.[21] The estimated IRFs for oil discovery news and oil revenue shocks are reported in Tables A.I and A.II in the online Supplementary Appendix.

In Figure I, the responses of the changes in NFA and total foreign assets/liabilities (all scaled by GDP) to oil discovery shocks and contemporaneous oil revenue shocks are displayed in the left column and the right column, respectively. The top graph in the left column shows that giant oil discoveries have a negative effect on the change in NFA as a percentage of GDP in the years immediately following their announcement. The average effect of the oil discovery news becomes positive five years after discovery. The peak effect has reached nine years following the announcement. After this period, however, the effect starts to decline. The swing from the negative to positive effects of discoveries on the change in NFA strongly supports the intertemporal approach to external adjustment. In anticipating an increase in future oil output, a country begins to borrow abroad first and then saves after oil production starts. The timing of the anticipation

[21] Driscoll and Kraay (1998) provide a consistent estimation of the covariance matrix for spatially dependent panel data, which are particularly relevant for studying external balance and country portfolio using cross-country data.

effect is also consistent with the average delay between oil discovery and production, that is, four to six years. On the contrary, the effect of contemporaneous oil revenue shocks on the change in NFA is sharply different, as shown in the top graph of the right column. The change in NFA increases immediately following the oil revenue shock. The positive effect persists for several years, although the increments in NFA rapidly decline in magnitude. The results for the oil revenue shocks are also consistent with the intertemporal approach to external adjustment. When a country receives a temporary contemporaneous income shock, it saves part of the windfall for the future by purchasing more foreign assets. The comparison between oil discovery new shocks and oil revenue shocks provides strong and direct support to the intertemporal view on external adjustment, which predicts that the responses of NFA adjustment are dependent on the timing of the shocks.

The middle and bottom panels show the effects of two oil shocks on the changes in the total foreign assets and liability positions. Following an oil discovery announcement, the change in total foreign liabilities increases and remains positive for approximately five years, indicating that the country borrows from abroad to finance booms in investments and consumption. The effect becomes negative six years after discovery, suggesting that the country begins to pay off the foreign liabilities when the oil field starts production. In comparison, oil discovery leads to an oscillating increase in total foreign assets for roughly eight years, but the positive effect only becomes significant after the first six years. In summary, the dynamic patterns of changes in total foreign assets and liability positions are consistent with the change in NFA. On the contrary, oil revenue shocks have similar qualitative dynamic effects on the changes in total foreign assets and liabilities. Changes in foreign assets and liabilities increase immediately after oil revenue shocks, but the effects decline quickly with a gradual rebound in ensuing years. However, the effect on the change in total foreign assets is much stronger than on the change in total foreign liabilities, resulting in a positive increase in NFA. The feature of two-way capital flows is consistent with portfolio diversification when a country receives a positive contemporaneous income shock (Tille and van Wincoop, 2010).

In theory, the change in NFA equals the summation of the current account and valuation effects due to the asset price changes of the country portfolio. As previously discussed, the growing debate regarding the relative importance of the current account and valuation effects casts doubt on the empirical relevance of the current account for external adjustment in academic and policy circles. However, the relative sizes of current account and valuation effects do not represent their contributions to intertemporal external adjustment, and empirically assessing their relative importance to external intertemporal adjustment is difficult. Theoretical research points out that the nature of shocks is important. For example, Evans (2014) showed that external balance following endowment shocks predominately adjusts via the current account channel, whereas the valuation effect is important to hedge risk preference shocks. Nguyen (2011) demonstrated that valuation effects tend to stabilize the current account movement with contemporaneous transitory shocks but amplify it with trend shocks. However, empirical studies have yet to investigate the empirical relevance of the current account and valuation effects in response to particular types of shocks. The present study offers a unique opportunity to examine which channel is more important for intertemporal external adjustment to oil shocks given that the empirical evidence of oil shocks on the changes in NFA supports the intertemporal theory.

In Figure II, the responses of the current account-GDP ratio and the valuation effects–GDP ratio to oil discovery shocks are presented in the left column, and responses to contemporaneous oil revenue shocks are presented in the right column. The top panel shows that the effects of the two types of oil shocks on the current account are similar to those on the change in NFA. The current account begins to run deficits immediately following the announcement of oil discovery and then becomes surplus five years later. The effect peaks eight years after the discovery and then begins to decline. This result is similar to the finding of ARS (2017), indicating that the effect of oil discovery news shock on the current account is robust to controlling for the contemporaneous oil revenue shock and its lagged values. On the contrary, contemporaneous oil revenue shocks lead to an immediate significant improvement in the current account, and then the positive effect declines gradually. These findings strongly support the key predictions of the intertemporal approach to the current account. A temporary contemporaneous income shock causes a country to run a current account surplus, whereas a news shock about future income leads to current account deficits in the short run.

The bottom panel displays the influence of the two types of oil shocks on valuation effects. Interestingly, as shown by the graph in the bottom left, valuation effects do not respond to discovery news shock. This finding implies that the external adjustment in NFA as a response to oil discovery shocks occurs entirely through the current account channel. On the contrary, contemporaneous oil revenue shocks cause valuation effects to swing from significantly negative in the first five years to slightly positive subsequently, indicating a decrease in the market value of foreign assets or an increase in the market value of the foreign liability. Thus, valuation effects partially offset the current account adjustment after an oil revenue shock in the short run. This result suggests that valuation effects stabilize the external adjustment on temporary oil revenue shocks, which is consistent with the theoretical finding in Nguyen (2011). It is also consistent with the standard portfolio diversification theory that oil exporters should hold some of their wealth in the form of assets in oil-importing economies (and vice versa). An increase in oil price boosts the profits and asset prices of oil-exporting economies, and portfolio diversification implies that some of the increased wealth associated with increased oil prices will be transferred from oil exporters to oil importers.[22] Thus, a positive temporary oil price shock should be associated with a temporary capital loss for oil exporters and a temporary capital gain for oil importers. In the long run, asset prices return to their steady state, and the valuation effects vanish.

The stabilization effect of the valuation channel is also supported by the common financial practice of oil exporters and importers in the management of their foreign assets. For example, many oil exporters have established large-scale sovereign wealth funds to smooth short-term variations in oil revenues by investing in public equities, private firms, and real estate globally. According to Sovereign Wealth Fund Institute, oil- and gas-related funds contributed 56% of the 7.4 trillion USD total sovereign wealth fund assets in July 2017. Half of the top 10 sovereign wealth funds are also from oil exporters, including the well-known Government Pension Fund in Norway, Abu Dhabi Investment Authority in UAE-Abu Dhabi, Kuwait Investment Authority, and SAMA Foreign Holdings in Saudi Arabia.[23] Oil exporters and importers also use financial instruments, such as oil put or call options, swap, and oil-denominated bonds, in the global financial market to hedge the risk of international oil price shocks. A well-known case is the Mexico oil hedge program, which purchases oil put options to hedge the downside risk of oil price to maintain stable oil export revenues for the Mexican government. The program helped cushion the fiscal impact of the decline in oil prices in 2009 and 2015 as the put options were exercised,

[22] Devereux and Sutherland (2009) presented a theoretical case that a contemporaneous productivity shock in home country leads to negative valuation effects as the return to foreign assets decreases, while the liability denominated in its own currency increases because of the exchange rate appreciation after the positive productivity shock.

[23] Data sourced from Sovereign Wealth Fund Institute: https://www.swfinstitute.org/sovereign-wealth-fund-rankings/.

yielding payoffs close to 0.6% of GDP on each occasion (IMF, 2016). Through the practice of portfolio diversification, valuation effects usually partially offset the current account adjustment and thus stabilize external adjustment in net foreign assets for Mexico.

In summary, our empirical results support the statement made by Obstfeld (2012) that current account adjustment remains an important channel for external adjustment. This finding may be unsurprising given that the two types of oil shocks considered here are more likely to affect international trade, and thus, the trade channel is more important for external adjustment than valuation effects. The stabilization effect of the valuation channel for oil revenue shocks in the short run could be substantial but is less likely to be anticipated because it is likely to be associated with the oil price, and forecasting oil price changes is difficult. This result is in line with Devereux and Sutherland (2010) that unanticipated valuation effects would be large, whereas the anticipated valuation effects are small in a reasonably calibrated model.

V. COUNTRY PORTFOLIO

We have shown that the current account channel plays the predominant role in intertemporal adjustment for oil shocks. Subsequently, we study how a country adjusts its international portfolio upon oil shocks to examine how a country finances its current account deficits upon oil discovery shocks and manages its assets from the improvement in the current account due to oil windfalls.

Figure III presents the evolution of the composition of world financial liabilities from 1970 to 2011. Debt and FDI are the most important instruments for international capital flows, they contribute more than 90% of the world's total liabilities before 1990, and their share has declined to approximately 74% in 2011. The portfolio equity assets have accelerated since 1990 due to financial innovation and rapid global financial market integration, and its share in the world total liabilities increased to 14 percent in 2011. Other financial assets including financial derivatives and foreign reserves did not play a significant role in the total stocks of world financial liabilities until the late 2000s.[24] Therefore, we study the effects of the two types of oil shocks on changes in assets and liabilities of FDI, debt, and equity instruments.

[24] The composition of world financial assets during the period between 1970 and 2011 presents a similar pattern.

In Figure IV, the responses of the changes in net FDI assets and total FDI assets/liabilities (as a percentage of GDP) to oil discovery shocks and oil revenue shocks are shown in the left and right columns, respectively. The top panel shows the effects of the two oil shocks on the changes in net FDI assets (or net FDI outflows). Oil discovery news immediately attracts a large amount of FDI inflows because of the booming demand for extraction investment and spillover effects on other sectors. The net FDI outflows become positive but are less significant five years after oil discoveries; then, this effect vanishes.[25] On the contrary, a positive oil revenue shock does not cause net FDI inflows but rather results in net FDI outflows; however, the effect is insignificant.

The middle and bottom panels of Figure IV show the effects of the two oil shocks on changes in total FDI assets and liability position (as a percentage of GDP). The total FDI assets and liabilities decline with a similar magnitude in the same year of the oil discovery announcement, but the FDI liabilities rebound more resiliently than FDI assets. The changes in total FDI assets are barely nil in the next four years following the year of discovery, whereas the changes in total FDI liabilities remain positive for approximately five years, thereby leading to significant net FDI inflows after oil discoveries. After five years, the effects on the changes in FDI liabilities and assets are largely reversed. The changes in assets become positive, whereas the changes in liabilities become slightly negative, resulting in net FDI outflow. The effects of oil revenue shocks on the changes in total FDI assets and liabilities are similar but insignificant most times, indicating that a country may hold more other assets after oil revenue shocks.

In Figure V, the responses of the changes in net foreign debt assets and in total foreign debt assets/liabilities (as a percentage of GDP) to the two oil shocks are presented in the left and right columns, respectively. The left column shows that the change in net foreign debt assets is slightly negative in the first few years after oil discovery because the increase in the total debt liability position is slightly larger than the changes in the total debt asset position. Five years after discovery, the change in net debt assets becomes positive, and the peak effect is reached in the eighth year and then begins to decline. A country slightly borrows from the international debt market after oil discovery and then begins to accumulate more foreign debt assets and pay off after oil production

[25] A limitation of FDI statistics is the lack of sectoral information; thus, we do not know whether only FDI inflows into the oil extraction industry increase after oil discovery. However, Toews and Vezina (2017) used transaction-level FDI data for a shorter period covering 2003 to 2012 and found that non-extraction FDI inflows also increase dramatically in the two years following a giant oil discovery.

starts. On the contrary, the right column shows that oil revenue shocks lead to a significant accumulation in the net and total debt assets for several years, and then the positive effect gradually vanishes. The effect on the change in total debt liabilities is largely negative but insignificant.

Lastly, we do not find a systematic response of foreign equity assets/liabilities to two oil shocks. Figure VI presents the responses of the changes in net foreign equity assets and total foreign equity assets/liabilities (as a percentage of GDP) to the two oil shocks. The left column shows that oil discoveries have insignificant effects on the adjustment of countries' holding in foreign equity assets. In the right column, we find some suggestive evidence that oil revenue shocks lead to a slight decline initially and then a rebound in net foreign equity assets. However, this evidence is relatively weak because the point estimates of the impulse response are all insignificant. Moreover, the impulse responses of the changes in total foreign equity assets/liabilities do not provide a clear pattern on how oil revenue shocks affect the adjustment in foreign equity assets/liabilities. This inconclusive result may be attributed to the low share of foreign equity assets/liabilities in the total foreign financial assets/liabilities during the early period of our sample before 1990. Therefore, in the subsequent analysis, we focus on the effects of two oil shocks on FDI and foreign debt assets.

In summary, oil discovery attracts a significant amount of FDI inflows accompanied by an uptick in foreign debt liability prior to oil production. This finding is consistent with the expectation of high returns in the future and international risk-sharing through FDI. Once oil production starts, a country pays off foreign liabilities and holds more foreign debt assets to hedge the risk of future domestic production. On the contrary, countries with positive oil revenue shock immediately increase their holdings in net foreign debt assets significantly compared with an uptick in net FDI assets. Therefore, oil producers prefer FDI inflows to share the risk of oil extraction after oil discovery and foreign debt assets for a stable and low-risk investment after oil revenue shocks. This pattern suggests that expectations of high return and international risk sharing are important determinants of international capital flows. Thus, country portfolio adjustments upon oil shocks are largely consistent with the standard portfolio diversification theory (Devereux and Sutherland, 2009; Tille and van Wincoop, 2010).

Not all point estimates of the estimated impulse responses differ from zero at conventional levels of significance. Following ARS (2017), we conduct the test for cumulative impulse responses over a certain horizon. For example, we test whether the *integral* of the responses of the change in NFA between the discovery of oil and the start of oil production is negative and whether the *integral* of the response of the change in NFA after an oil revenue shock during the same horizon is positive. The hypothesis tests for the relevant integrals are presented in Table III.

Our results show that in most cases, the null hypothesis can be rejected in favor of the theoretical prediction of intertemporal theory at standard levels of statistical significance. For example, the response of the ratio of change in NFA to GDP to oil discovery shock is significantly negative between discovery and production and becomes significantly positive after oil production starts. On the contrary, the response of the ratio of change in NFA to GDP to oil revenue shocks is significantly positive at five-year or 10-year horizons. The results are similar for the current account–GDP ratio. These findings strongly support the intertemporal approach to external adjustment that a country should borrow after an income news shock but save for a temporary contemporaneous income shock. The valuation effects are insignificant overall upon oil discovery news. However, the valuation effects for oil revenue shocks are significantly negative in the first five-year horizon, and the effects become significantly positive in the second five years.

The ratio of change in total foreign liability–GDP is significantly positive in the first five years after oil discovery but not for the following years. On the contrary, the ratio of change in total foreign assets–GDP is insignificant from zero initially but becomes positive during the second five years. We also find that the ratio of change in net FDI assets–GDP is significantly negative in the first five years. Consistently, the ratio of changes in total FDI liability–GDP is significantly positive for the first five years, whereas the ratio of change in total FDI assets–GDP is significantly negative initially and then becomes significantly positive after five years. The ratio of change in net foreign debt assets–GDP is negative but statistically insignificant in the first five years after discovery. However, it becomes significantly positive subsequently. For oil revenue shocks, the ratio of change in total foreign assets–GDP is significantly positive at five-year or 10-year horizons, whereas the effect on the liabilities is insignificant. The effect of oil revenue shocks on the country portfolio on FDI assets is insignificant, whereas the effects on the ratios of the change in the net or total debt assets–GDP are significantly positive at 5-year and 10-year horizons.

Quantitatively, we consider a typical oil discovery with the NPV equal to the median value (9% of the initial GDP) and an oil revenue shock equal to 1% of GDP (the mean is 0.13% of GDP).

A typical oil discovery leads to a decline in NFA in the short run by 0.6% of GDP and rises in the intermediate run to a peak of 0.4% of GDP. The quantitative effect on the current account is similar. Upon the same size of a discovery shock, the current account falls by 0.58% of GDP in the short run and reaches the peak of 0.36% of GDP eight years after oil discovery. This result confirms the previous finding that the adjustment in NFA almost entirely occurs through the current account channel. As for the country portfolio, the same size of a discovery shock leads to FDI inflows by 0.6% of GDP in the short run, thereby providing funds for a similar size of current account deficits. A country does not borrow significantly from abroad through the international debt market (only 0.07% of GDP) immediately after oil discoveries but instead increases its net holdings in foreign debt assets after oil production starts. The peak effect on net foreign debt assets is roughly 0.34% of GDP eight years after discovery, and the peak effect on net FDI assets is only approximately 0.06% of GDP.

Based on the estimated impulse response for oil revenue shocks, an oil revenue shock equal to 1% of GDP leads to a cumulative increase in the NFA by approximately 1% of GDP in the following 10 years.[26] Meanwhile, the current account increases cumulatively by roughly 1.31% of GDP in 10 years. This increase is partially offset by the negative valuation effects for approximately 0.38% of GDP. The negative valuation effects offset 60% of the current account surplus in the first five years, indicating that valuation effects can substantially stabilize the current account adjustment in the short run. This finding is consistent with Nguyen (2011), who suggested that valuation effects tend to stabilize the current account movement with transitory shocks. The current account surplus is accompanied by a significant increase in the net holdings of foreign debt assets (1.1% of GDP) and a negligible uptick in the net holdings of FDI assets (0.04% of GDP) in 10 years.

[26] For simplicity, we compute the simple cumulative changes in NFA within 10 years after oil revenue shock. The large magnitude of the effect of oil revenue shock on NFA may be attributed to the fact that oil revenue shocks based on net exports of oil and gas may underestimate the effect of international oil price on external balance. In the robustness check, we also use the total exports or production of oil and gas to measure oil revenue shocks and find that the same size of an oil revenue shock based on total exports (or production) leads to a cumulative increase in the NFA of approximately 0.6% or 0.8% of GDP in the next 10 years after the shock.

VI. Remarks on Key Identification Assumptions

Our empirical identification relies on three underlying assumptions. First, countries have different degree of financial openness which may play an important role in shaping the responses of countries' external balance and portfolio to oil shocks. Second, we implicitly assume that oil discovery news and oil revenue shocks from changes in the oil price are unanticipated in the previous analysis. Third, international oil price shocks are assumed to be exogenous to countries' economic conditions when we construct the country-specific oil revenue shocks. Then, we discuss these three issues in detail.

Financial openness. The degree of financial openness may affect the responses of external balance and country portfolio to oil shocks. If a country cannot borrow from or lend to the world financial market, then the external balance should not respond to any of the two types of oil shocks. If a country does not allow for FDI or foreign debt flows, then the effects on country portfolio also differ. Notably, the magnitude of valuation effects crucially depends on the size of total foreign assets and liabilities that a country holds. Thus, we test whether the effects of oil shocks on external adjustment and country portfolio across countries depend on their degree of financial openness.

We use the ratio of total assets and liabilities to GDP to measure the level of financial openness.[27] We calculate the average of this index for each country and take the median as the threshold to determine whether a country is financially open (above the threshold) or financially closed (below the threshold). We then re-estimate the main regressions separately for the two groups of countries. As shown in Figure VII, the responses of changes in NFA, the current account, net FDI inflows, and changes in net debt assets are roughly similar for the two groups of countries. Countries with oil discoveries may use oil fields as collateral for external borrowing, and oil revenues are largely in U.S. dollars, which are globally liquid.[28] However, the magnitude of valuation effects for oil revenue shocks is considerably smaller in financially closed countries than in financially open economies. This finding is consistent with that of Obstfeld (2012)'s conjecture

[27] An alternative measure of financial openness is the Chinn–Ito (2006) index, which is widely used in the international finance literature on capital account openness. This index is a *de jure* measure for a country's degree of capital account openness because it is based on the binary dummy variables that codify the tabulation of restrictions on cross-border financial transactions reported in the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions.* The results are robust to this alternative index.

[28] We do not find evidence that the responses to two types of oil shocks for Sub-Saharan African countries are any different from the overall responses for other countries.

that valuation effects might be relatively small in less-developed countries because they have fewer foreign assets and liabilities than developed countries.

Predictability of oil shocks. A potential concern arises in the assumption that oil discovery news and revenue shocks may be anticipated to an extent. Given that the timings of two oil shocks are crucial for identifying the effects of news and contemporaneous shocks, whether oil discoveries or oil revenues are anticipated becomes a central problem. To ease this concern, we selectively use discoveries that occurred when no discoveries had occurred in the last three years because discoveries that follow others are likely to be criticized as predictable. For oil revenue shocks, we estimate a panel AR(3) model of the original net export oil revenue with a dummy variable indicating whether a giant oil discovery occurred in the past 10 years and the country- and year-fixed effects.[29] We then obtain the residual from the regression as the measure of unanticipated oil revenue shocks by assuming that countries may use their lagged oil revenues and discoveries in the past 10 years to forecast their current oil net exports revenues.[30] Figure VIII shows the responses of changes in NFA, the current account, valuation effect, net FDI inflows, and changes in net debt assets to the two "unanticipated" oil shocks, and the results are virtually the same as the baseline findings.

Exogeneity of oil price changes. The third concern is that oil price changes may not be exogenous particularly for the main oil producers and consumers because they may have monopoly power over international oil prices. To ease this concern, we exclude the top 10 global largest oil producers and consumers. EIA data for 2016 showed that the top 10 producers account for approximately 67% of world oil production, and the top 10 consumers account for roughly 57% of world oil consumption.[31] Moreover, OPEC has been historically notorious for manipulating the

[29] We select panel AR(3) because the coefficients of the first two lagged terms are significant and the third lag term is insignificant. However, both AIC and BIC statistics indicate that the panel AR(3) model is preferred.

[30] An alternative approach to construct the unanticipated oil revenue shocks is to obtain the residuals from the estimation of an AR(p) model for the change in international oil price, and then multiply the GDP share of net exports of oil and gas. However, we find that the lagged value of oil price changes does not have predictive power for the current change in oil price. For example, the coefficients of the lagged value of oil price changes is close to zero and insignificant when we use an AR(3) model for oil price changes. This finding is consistent with the fact that forecasting international oil prices is very difficult.

[31] According to the U.S. Energy Information Administration, the top 10 largest producers in 2016 are the U.S., Saudi Arabia, Russia, China, Canada, Iraq, Iran, United Arab Emirates, Brazil, and Kuwait. The top 10 largest consumers are the U.S., China, India, Japan, Russia, Saudi Arabia, Brazil, South Korea, Canada, and Germany. Source: https://www.eia.gov/tools/faqs/faq.php?id=709&t=6.

international oil price by adjusting its oil production level.[32] Its power was first demonstrated during the 1973 oil crisis. In resentment of the Western support of Israel in the Yom Kippur War, OPEC countries launched the oil embargo, which caused the international oil price to triple within a year. Thus, we also check whether the main results are robust if the member countries of OPEC are excluded from the sample. Besides, giant oil discoveries are relatively concentrated in the region of the Middle East and North Africa. Thus, this region becomes a main oil supplier in the world market. We also exclude all countries in this region for the robustness check. The main results are virtually unchanged for the three subsamples as shown in Figures A.I–A.III in the Supplementary Appendix A.

Lastly, the variation in international oil price changes during the 1960s to early 1970s is much smaller than the oil price fluctuations after the 1973 oil crisis, and therefore forecasting oil price prior to 1973 may be easier.[33] Thus, we also check the results by using the oil shocks after the first oil crisis in 1973 and find similar impulse responses to the two oil shocks (Figure A.IV in the Supplementary Appendix A).

VII. ROBUSTNESS

In this section, we conduct an extensive robustness analysis for the baseline specification of five key variables, as follows: changes in NFA, the current account, valuation effects, and changes in net FDI or foreign debt assets (all scaled by GDP). First, we include additional control variables to control other confounding factors and possible trends in external adjustment. Second, we adopt different measures of oil discoveries and oil revenue shocks to check whether the results are sensitive to our construction methods for two oil shocks. Third, we conduct our analysis for different samples of countries. Lastly, to check whether our results are sensitive to our econometric specifications and estimation method, we also use alternative specifications for the dynamic panel model with distributed lags and the alternative estimation method. To save space, all figures discussed in this section are presented in the online Supplementary Appendix A.

---

[32] See Barsky and Kilian (2004) for a detailed discussion on the market power of the OPEC. However, they argued that the conventional view may overstate the market power of OPEC in the international oil market.

[33] Hamilton (2009) pointed out that oil prices were stable over the four decades prior to the first oil crisis in 1973 but became increasingly volatile subsequently.

Additional control variables. In the baseline specification, we adopt a parsimonious specification by only including country and year fixed effects and relying on the exogeneity of two oil shocks. At present, we include other macroeconomic variables that may affect the countries' external balance. First, poor countries are usually less open than advanced economies, and their external adjustment might be limited. Thus, we include the log GDP per capita to capture the development level. Second, to control for the cyclicality in external adjustment, the GDP growth rate and inflation rate are included to capture the business cycle. Third, oil price shocks are not pure-income shocks, but also indicate changes in relative prices which may affect a country's terms of trade. To capture the possible contagious effects on external balance through the terms of trade, we also include the changes in terms of trade and official exchange rates in regressions.

Moreover, the oil price may be driven by the global demand, as shown in Kilian (2009). High global demand is likely to be associated with high inflation or real interest rate given that central banks attempt to stabilize inflation, which in turn affects saving and investment decisions and countries' external balance. Thus, ignoring the global demand may lead to an omitted variable bias. The time-fixed effects included in our regression appropriately control for the global demand, assuming that the effects of global demand are homogenous across countries. This assumption may not hold because the degree of openness varies across countries and the global demand may have differential effects on the countries' external adjustment. To address this issue, we construct a country-specific exposure to global demand, by interacting the country's average ratio of exports of goods and services to GDP with the weighted annual GDP growth rate of G4 countries including the US, Germany, Japan, and China.[34] As shown in Figure A.V of the supplementary appendix, including the additional control variables does not alter our main results.

Possible trends in external adjustment. Lane and Milesi–Ferretti (2007) showed that the international financial integration measured as the ratio of the sum of total foreign assets and liabilities to GDP has gradually increased from 1970 to 2004, with acceleration in the cross-border assets trade by industrial countries. This finding indicates that countries may exhibit different trends in their external balance and international portfolio. Therefore, we include country-specific

[34] All the macroeconomic variables included in the regression are from World Development Indicators provided by the World Bank except the terms of trade from Penn World Table (version 9.1). The US, Germany, Japan, and China are excluded in the regression sample.

linear trends in the baseline regression, but the main results are virtually unchanged, as shown in Figure A.VI.

Alternative measures of oil shocks. We explore whether the main results are sensitive to the alternative measures of two types of oil shocks. To ease concerns regarding the construction of NPV of giant oil discoveries, we use a simple dummy variable for an oil discovery event. The impulse responses of the five key variables to two oil shocks are virtually the same, as shown in Figure A.VII.

The weights used to construct the country-specific oil revenue shocks may also be a concern. First, using the GDP share of net exports of oil and gas may underestimate the effect of international oil price changes on the income of oil exporters. Thus, we also use the lagged GDP share of total exports or production of oil and gas to construct the oil revenue shocks. Second, the lagged GDP share of net exports of oil and gas is a time-varying weight, which might introduce additional variations in the oil revenue shocks. To ease this concern, we use the country's average GDP share of the net exports of oil and gas during the sample period or in the past three years as the weights to construct the oil revenue shocks. We find that our results are robust to those alternative measures of oil revenue shocks, as shown in Figure A.VIII–A.XI.

Sample of oil exporters. In our baseline estimation, the sample covers all countries in the world, including exporters and importers of oil and gas. Thus, this sample also uses the variations of oil price shocks on oil importers. For instance, a hike in oil price acts as a negative oil income shock to oil importers. However, one may be concerned that the oil price shock might have different effects on oil importers and oil exporters as the relative price effects might be more important for oil importers. To address this concern, we limit our sample to main oil exporters, which are the country's average exports of oil and gas above the median value. The sample of countries is reduced to 86, but the estimation results are similar to our baseline, as shown in Figure A.XII. We also examine the sample of countries with at least one giant oil discovery, which only covers 64 countries, and the baseline results remain to hold, as shown in Figure A.XIII.

Alternative specifications. The baseline results are also robust to the use of different dynamic specifications. In particular, the inclusion of high-order lags for the dependent variable, such as $p = 2$, does not alter the main results. Moreover, we adopt a flexible specification by using different orders in the lags for two types of oil shocks, i.e., $q = 11$ for oil discoveries and $q = 8$ for oil revenue shocks. The results are virtually unchanged, as shown in Figures A.XIV and A.XV.

Alternative econometric method. One potential econometric issue about the baseline dynamic panel model is that the oil shocks might have heterogeneous effects across individual countries, i.e., the coefficients of $A(L)$, $B(L)$, and $C(L)$ might be country-specific. In this case, the fixed effect estimators are inconsistent for the dynamic panel with heterogeneous slopes (Pesaran and Smith, 1995), as well as the computed impulse responses from $B(L)/(1 - A(L))$ and $C(L)/(1 - A(L))$. Our object of interest is to estimate the population-averaged impulse responses rather than the country-specific impulse responses of two types of oil shocks.[35] Thus, we adopt Chang and Sakata's (2007) "long autoregression" method, which is equivalent to Jordà's (2005) local projections method to estimate impulse responses directly. The local project method obtains the impulse response γ_h by regressing the dependent variable y_{it} on the h period lagged independent variables X_{it-h} with a static panel fixed effect model for different horizons $h = 1,2, \dots, H$. Wooldridge (2005) showed that the fixed effect estimators consistently estimate the population-averaged slope coefficients in the static panel data models with individual-specific slopes under broad conditions.[36] Thus, we can obtain consistent estimates of the population-averaged impulse responses for two types of oil shocks by using the local project method. The estimated impulse responses are more volatile because this method imposes fewer dynamic restrictions than the baseline model. However, the results mostly demonstrate similar patterns to the results obtained through the baseline model for the relevant horizons, as shown in Figure A.XVI.

[35] We also tried to adopt the mean group estimator and its variants proposed by Pesaran and Smith (1995), which compute the population-averaged slopes by averaging the estimated country-specific impulse responses in the first step. However, estimating country-specific impulse responses are technically difficult and less reliable in our case because the incidence of giant oil discoveries is low in general and only a few countries have multiple discoveries and sufficient frequencies to allow estimating the country-specific impulse responses of oil discoveries.

[36] In the standard random coefficient model of panel data, the fixed effect estimators are consistent for the population-averaged slopes. Wooldridge (2005) further relaxed the condition and show that this also hold if the individual-specific slopes are mean-independent of the time-demeaned covariates, which implies that the fixed effect estimators are consistent even in cases when the individual slopes are correlated with the covariates.

VIII. Conclusion

We provide several empirical contributions to the intertemporal approach to external adjustment. First, we present direct evidence for the key theoretical prediction of the intertemporal approach that the NFA declines when expecting higher future income but increases if the current income rises unexpectedly and temporarily. Although our approach is different from the present value test, which is model-based and thus more rigorous, our empirical evidence using two oil income shocks sheds light on the crucial role of timing in the intertemporal approach to external adjustment.

Second, we directly compare the current account and valuation effects as the intertemporal external adjustment mechanism upon oil shocks and find that external adjustments largely occur through the current account. Our finding is in line with the view of Obstfeld (2012) that current account adjustment remains an important channel for external balance (at least for oil shocks) in the era of financial globalization. We also find that valuation effects are negligible for oil discovery news but substantially stabilize the current account adjustment after oil revenue shocks in the short run. Our results suggest that more empirical studies are required for the relative importance of valuation effects and current account. Nevertheless, future research should focus on the nature and timing of the shocks. However, we should not interpret the results of this study as evidence for denying the importance of valuation effects. Instead, exploring whether valuation effects play an important role in response to risk preference and financial shocks for international risk sharing will be particularly valuable.

Our study casts light on country portfolio adjustment upon oil shocks, and our results are largely consistent with the portfolio diversification theory. Thus, we provide an interesting empirical benchmark for modeling the portfolio choice in open macroeconomic models. Finally, we also contribute to the literature on the macroeconomic effects of oil shocks for oil importers and exporters. Previous studies usually only focused on contemporaneous oil revenue shocks. On the contrary, our study explores oil news shocks and contemporaneous oil revenue shocks and emphasizes that the timing of the shocks plays a key role in their differential dynamic effects on a country's external adjustment.

References

Acemoglu, Daron, Amy Finkelstein, and Matthew J. Notowidigdo. "Income and health spending: Evidence from oil price shocks." Review of Economics and Statistics 95, no. 4 (2013): 1079-1095.

Arezki, Rabah, and Markus Brückner. "Commodity windfalls, polarization, and net foreign assets: Panel data evidence on the voracity effect." Journal of International Economics 86, no. 2 (2012): 318-326.

Arezki, Rabah, Valerie A. Ramey, and Liugang Sheng, "News Shocks in Open Economies: Evidence from Giant Oil Discoveries," The Quarterly Journal of Economics, 132.1 (2017), 103-155.

Barro, Robert J., and Charles J. Redlick, "Macroeconomic Effects from Government Purchases and Taxes," The Quarterly Journal of Economics, 126.1 (2011), 51-102.

Barsky, Robert B., and Lutz Kilian, "Oil and the Macroeconomy since the 1970s," The Journal of Economic Perspectives, 18.4 (2004), 115-134.

Beaudry Paul and Franck Portier. "Stock Prices, News, and Economic Fluctuations." American Economic Review, 96.4 (2006): 1293-1307.

Bergin, Paul R., and Steven M. Sheffrin, "Interest Rates, Exchange Rates and Present Value Models of the Current Account," The Economic Journal, 110.463 (2000), 535-558.

Bernanke, Ben. "Remarks by Governor Ben S. Bernanke: The Global Saving Glut and the US Current Account Deficit." The Sandridge Lecture, Virginia Association of Economics, Richmond, VA, March 10, 2005.

Brückner, Markus, Antonio Ciccone, and Andrea Tesei. "Oil price shocks, income, and democracy." Review of Economics and Statistics 94, no. 2 (2012): 389-399.

Brueckner, Markus, and Hannes Schwandt. "Income and population growth." The Economic Journal 125, no. 589 (2015): 1653-1676.

Bruno, Michael, and Jeffrey Sachs, “Energy and Resource Allocation: A Dynamic Model of the “Dutch Disease”,” The Review of Economic Studies, 49.5 (1982), 845-859.

Bodenstein, Martin, Christopher J. Erceg, and Luca Guerrieri, “Oil Shocks and External Adjustment,” Journal of International Economics, 83.2 (2011), 168-184.

Chang, Pao-Li, and Shinichi Sakata, “Estimation of Impulse Response Functions Using Long Autoregression,” Econometrics Journal, 10 (2007), 453-469.

Chinn, Menzie D., and Hiro Ito, “What Matters for Financial Development? Capital Controls, Institutions, and Interactions,” Journal of Development Economics, 81.1 (2006), 163-192.

Caselli, Francesco, and Andrea Tesei. "Resource windfalls, political regimes, and political stability." Review of Economics and Statistics 98, no. 3 (2016): 573-590.

Corsetti, Giancarlo, and Panagiotis T. Konstantinou, “What Drives US Foreign Borrowing? Evidence on the External Adjustment to Transitory and Permanent Shocks,” American Economic Review, 102.2 (2012), 1062-1092.

Cotet, Anca M., and Kevin K. Tsui, “Oil and Conflict: What Does the Cross Country Evidence Really Show?” American Economic Journal: Macroeconomics, 5.1 (2013), 49-80.

Curcuru, Stephanie E., Tomas Dvorak, and Francis E. Warnock, “Cross-Border Returns Differentials,” The Quarterly Journal of Economics, 123.4 (2008), 1495-1530.

Curcuru, Stephanie E., Charles P. Thomas, and Francis E. Warnock. “On returns differentials.” Journal of International Money and Finance 36 (2013): 1-25.

Devereux, Michael B., and Alan Sutherland, “A Portfolio Model of Capital Flows to Emerging Markets,” Journal of Development Economics, 89.2 (2009), 181-193.

Devereux, Michael B., and Alan Sutherland, “Valuation Effects and the Dynamics of Net External Assets,” Journal of International Economics, 80.1 (2010), 129-143.

Devereux, Michael B., and Alan Sutherland, “Country Portfolios in Open Economy Macro Models,” Journal of the European Economic Association, 9.2 (2011), 337-369.

Driscoll, John C., and Aart C. Kraay, “Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data,” Review of Economics and Statistics, 80.4 (1998), 549-560.

Evans, Marin D., “Risk, External Adjustment and Capital Flows,” Journal of International Economics, 92 (2014), S68-S93.

Ghironi, Fabio, Jaewoo Lee, and Alessandro Rebucci, “The Valuation Channel of External Adjustment,” Journal of International Money and Finance 57 (2015): 86-114.

Ghosh, Atish R., and Jonathan D. Ostry, “The Current Account in Developing Countries: A Perspective from the Consumption-Smoothing Approach,” World Bank Economic Review, 9 (1995), 305–333.

Glick, Reuven, and Kenneth Rogoff, “Global Versus Country-specific Productivity Shocks and the Current Account,” Journal of Monetary Economics, Elsevier, 35.1 (1995): 159-192.

Gourinchas, Pierre-Oliver, and Helene Rey, “International Financial Adjustment,” Journal of Political Economy, 115.4 (2007), 665-703.

Gourinchas, Pierre-Oliver, and Helene Rey, “External Adjustment, Global Imbalances, Valuation Effects,” Handbook of International Economics, 4(2014), 585-645.

Hamilton, James D, “Causes and Consequences of the Oil Shock of 2007–08,” Brookings Papers on Economic Activity 1 (2009), 215-261.

Heathcote, Jonathan, and Fabrizio Perri, “The International Diversification Puzzle Is Not as Bad as You Think,” Journal of Political Economy, 121.6 (2013), 1108-1159.

Horn, Myron K., and K. Myron. “Giant Oil and Gas Fields of the World,” American Association of Petroleum Geologists Datapages, (2014).

International Monetary Fund, “Mexico: Selected Issues,” IMF Country Report No. 16/360 (2016).

Jordà, Òscar, “Estimation and Inference of Impulse Responses by Local Projections,” American Economic Review, 95.1 (2005), 161-182.

Ju, Jiandong, Kang Shi, and Shang-Jin Wei, “On the Connections between Intra-temporal and Intertemporal Trades,” Journal of International Economics 92 (2014): S36-S51.

Kilian, Lutz, “Not All Oil Price Shocks are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market,” The American Economic Review, 99.3 (2009), 1053-1069.

Kilian, Lutz, Alessandro Rebucci, and Nikola Spatafora, “Oil Shocks and External Balances,” Journal of International Economics, 77.2 (2009), 181-194.

Lane, Philip R., and Gian M. Milesi-Ferretti. “The External Wealth of Nations: Measures of Foreign Assets and Liabilities for Industrial and Developing Countries,” Journal of International Economics, 55.2 (2001), 263-294.

Lane, Philip R., and Gian M. Milesi-Ferretti, “The External Wealth of Nations Mark II: Revised and Extended Estimates of Foreign Assets and Liabilities, 1970–2004,” Journal of International Economics, 73 (2007), 223-250.

Lee, Junsoo, and Mark C. Strazicich. "Minimum Lagrange multiplier unit root test with two structural breaks." Review of economics and statistics 85.4 (2003): 1082-1089.

Lee, Nayoung, Hyungsik Roger Moon, and Qiankun Zhou. "Many IVs estimation of dynamic panel regression models with measurement error." Journal of Econometrics 200, no. 2 (2017): 251-259.

Lei, Yu-Hsiang, and Guy Michaels, “Do Giant Oilfield Discoveries Fuel Internal Armed Conflicts?” Journal of Development Economics, 110 (2014), 139-157.

McGrattan, Ellen R., and Edward C. Prescott. “Technology capital and the US current account.” American Economic Review, 100.4 (2010): 1493-1522.

Mertens, Karel, and Morten O. Ravn, “Empirical Evidence on the Aggregate Effects of Anticipated and Unanticipated US Tax Policy Shocks,” American Economic Journal: Economic Policy, 4.2 (2012), 145-81.

Nason, James M., and John H. Rogers. “The Present-Value Model of the Current Account as been Rejected: Round up the Usual Suspects,” Journal of International Economics, 68.1 (2006), 159-187.

Nguyen, Ha, “Valuation Effects with Transitory and Trend Productivity Shocks,” Journal of International Economics, 85.2 (2011), 245-255.

Obstfeld, Maurice, “Aggregate Spending and the Terms of Trade: Is There a Laursen-Metzler Effect?” The Quarterly Journal of Economics, 97.2 (1982), 251-270.

Obstfeld, Maurice, “Does the Current Account Still Matter?” The American Economic Review, 102.3 (2012), 1-23.

Obstfeld, Maurice, and Kenneth Rogoff, “The Intertemporal Approach to the Current Account,” Handbook of International Economics, 3 (1995), 1731-1799.

Obstfeld, Maurice, and Kenneth S. Rogoff, Foundations of International Macroeconomics, Vol. 30, (Cambridge, MA: MIT Press, 1996).

Otto, Glenn, “Testing a Present-Value Model of the Current Account: Evidence from US and Canadian Time Series,” Journal of International Money and Finance, 11.5 (1992), 414-430.

Pavlova, Anna, and Roberto Rigobon, “An Asset-Pricing View of External Adjustment,” Journal of International Economics, 80.1 (2010), 144-156.

Pavlova, Anna, and Roberto Rigobon, “Equilibrium Portfolios and External Adjustment under Incomplete Markets,” working paper, (2015).

Pesaran, M. Hashem, and Ron Smith. "Estimating long-run relationships from dynamic heterogeneous panels." Journal of Econometrics 68, no. 1 (1995): 79-113.

Ramey, Valerie A., “Identifying Government Spending Shocks: It's All in the Timing,” Quarterly Journal of Economics, 126.1 (2011), 1-50.

Rebucci, Alessandro, and Nikola Spatafora, “Oil Prices and Global Imbalances,” IMF World Economic Outlook, 4.2006 (2006), 71-96.

Ross, Michael, and Paasha Mahdavi, “Oil and Gas Data, 1932-2014,” Harvard Dataverse (2015).

Sachs, Jeffrey D, “The Current Account and Macroeconomic Adjustment in the 1970s,” Brookings Papers on Economic Activity, 12.1 (1981), 201-282.

Sheffrin, Steven M., and Wing Thye Woo, “Present Value Tests of an Intertemporal Model of the Current Account,” Journal of International Economics, 29.3 (1990), 237-253.

Schmitt-Grohé, Stephanie, and Martin Uribe. 2012. "What's News in Business Cycles.” Econometrica, 80(6): 2733-2764.

Svensson, Lars EO. “Oil Prices, Welfare, and the Trade Balance,” The Quarterly Journal of Economics, 99.4 (1984), 649-672.

Tille, Cedric, and Eric Van Wincoop, “International Capital Flows,” Journal of International Economics, 80.2 (2010), 157-175.

Toews, Gerhard, and Pierre-Louis Vézina, “Resource Discoveries and FDI Bonanzas,” OxCarre Working Paper No. 177, 2017.

Uribe, Martin, and Stephanie Schmitt-Grohé. Open economy macroeconomics. Princeton University Press, 2017.

Wooldridge, Jeffrey M. "Fixed-effects and related estimators for correlated random-coefficient and treatment-effect panel data models." Review of Economics and Statistics 87, no. 2 (2005): 385-390.

Table I: Spatial and Temporal Distribution of Giant Oil Discoveries (1960–2011)

Region	1960s	1970s	1980s	1990s	2000s	2010s	Total
Asia	17	17	14	20	23	0	91
Commonwealth of Independent States and Mongolia	27	22	12	4	10	3	78
Europe (including Central and Eastern Europe)	8	17	5	7	3	5	45
Middle East and North Africa	49	36	15	23	18	5	146
Sub-Saharan Africa	9	5	6	9	9	9	47
Western Hemisphere	10	20	15	16	21	2	84
Total	120	117	67	79	84	24	491

Note: The figures in the table reflect the total number of “discovery events” for a given decade and a given region. A discovery event is a dummy variable that takes a value of 1 if during a given year at least one discovery of either a giant oil or gas field was made in any given country, and zero otherwise. The data are from Mike Horn, and the country grouping is from the International Monetary Fund.

Table II: Summary Statistics

Variable	Years	Max num of countries	Obs	Mean	Std	Min	Max
ΔNFA/GDP	1971-2011	189	6307	-1.91	23.65	-677.7	747.4
ΔTotal foreign asset/GDP	1971-2011	189	6320	10.93	89.59	-1445	2979
ΔTotal foreign liability/GDP	1971-2011	189	6323	12.88	85.9	-1464	2632
CA/GDP	1970-2011	189	6367	-3.08	12.44	-244.6	106.8
Valuation effect/GDP	1971-2011	189	6033	1.31	21.27	-664.3	753
ΔNet FDI asset/GDP	1971-2011	189	6351	-2.42	11.41	-236.9	595.5
ΔFDI asset/GDP	1971-2011	189	6351	2.3	37.28	-225.9	1834
ΔFDI liability/GDP	1971-2011	189	6394	4.7	38.93	-241.4	2003
ΔNet foreign debt asset/GDP	1971-2011	189	6338	-0.82	26.36	-363.5	772.8
ΔForeign debt asset/GDP	1971-2011	189	6387	5.3	44.91	-636.8	1408
ΔForeign debt liability/GDP	1971-2011	189	6355	6.15	28.69	-342.6	811.8
ΔNet foreign equity asset/GDP	1971-2011	189	6271	-0.19	23.8	-643.1	741.4
ΔForeign equity asset/GDP	1971-2011	189	6324	1.65	30.46	-1193	802.6
ΔForeign equity liability/GDP	1971-2011	189	6319	1.84	39.76	-1368	1257
NPV of oil discovery/GDP	1962-2011	64	351	53.89	327.5	0.04	5873
Oil revenue shock/GDP based on net oil exports	1961-2011	185	7314	0.13	4.29	-37.64	111.6
Oil revenue shock/GDP based on oil exports	1961-2011	185	7314	0.51	5.72	-38.32	285.6
Oil revenue shock/GDP based on oil production	1961-2011	185	7314	0.85	6.83	-61.93	146.4

Note: all variables are in percentage.

Table III: Hypothesis Testing for Two Types of Oil Shocks

	P-value	
Variable	News shock	Contemporaneous shock
ΔNFA/GDP	$Pr(H_0: S_1 >= 0) = 0.05$	$Pr(H_0: S_1 <= 0) = 0.03$
	$Pr(H_0: S_2 <= 0) = 0.01$	$Pr(H_0: S_2 <= 0) = 0.05$
ΔTotal foreign asset/GDP	$Pr(H_0: S_1 >= 0) = 0.70$	$Pr(H_0: S_1 <= 0) = 0.08$
	$Pr(H_0: S_2 <= 0) = 0.03$	$Pr(H_0: S_2 <= 0) = 0.05$
ΔTotal foreign liability/GDP	$Pr(H_0: S_1 <= 0) = 0$	$Pr(H_0: S_1 >= 0) = 0.49$
	$Pr(H_0: S_2 >= 0) = 0.14$	$Pr(H_0: S_2 >= 0) = 0.33$
CA/GDP	$Pr(H_0: S_1 >= 0) = 0.02$	$Pr(H_0: S_1 <= 0) = 0.01$
	$Pr(H_0: S_2 <= 0) = 0.02$	$Pr(H_0: S_2 <= 0) = 0.14$
Valuation effect/GDP	$Pr(H_0: S_1 >= 0) = 0.51$	$Pr(H_0: S_1 >= 0) = 0.01$
	$Pr(H_0: S_2 <= 0) = 0.47$	$Pr(H_0: S_2 <= 0) = 0.07$
ΔNet FDI asset/GDP	$Pr(H_0: S_1 >= 0) = 0$	$Pr(H_0: S_1 <= 0) = 0.17$
	$Pr(H_0: S_2 <= 0) = 0.14$	$Pr(H_0: S_2 <= 0) = 0.66$
ΔFDI asset/GDP	$Pr(H_0: S_1 >= 0) = 0.01$	$Pr(H_0: S_1 <= 0) = 0.46$
	$Pr(H_0: S_2 <= 0) = 0$	$Pr(H_0: S_2 <= 0) = 0.82$
ΔFDI liability/GDP	$Pr(H_0: S_1 <= 0) = 0$	$Pr(H_0: S_1 >= 0) = 0.32$
	$Pr(H_0: S_2 >= 0) = 0.68$	$Pr(H_0: S_2 >= 0) = 0.31$
ΔNet foreign debt asset/GDP	$Pr(H_0: S_1 >= 0) = 0.38$	$Pr(H_0: S_1 <= 0) = 0.01$
	$Pr(H_0: S_2 <= 0) = 0.01$	$Pr(H_0: S_2 <= 0) = 0.02$
ΔForeign debt asset/GDP	$Pr(H_0: S_1 >= 0) = 0.7$	$Pr(H_0: S_1 <= 0) = 0.02$
	$Pr(H_0: S_2 <= 0) = 0.06$	$Pr(H_0: S_2 <= 0) = 0.04$
ΔForeign debt liability/GDP	$Pr(H_0: S_1 <= 0) = 0.25$	$Pr(H_0: S_1 >= 0) = 0.44$
	$Pr(H_0: S_2 >= 0) = 0.03$	$Pr(H_0: S_2 >= 0) = 0.14$

Note: S_1 denotes the cumulative sum of the estimated impulse response during 0–4 horizons, and S_2 denotes the cumulative sum of the estimated impulse response during 5–9 horizons. The alternative hypothesis is the opposite of the null hypothesis. P-values are obtained using the Delta method.

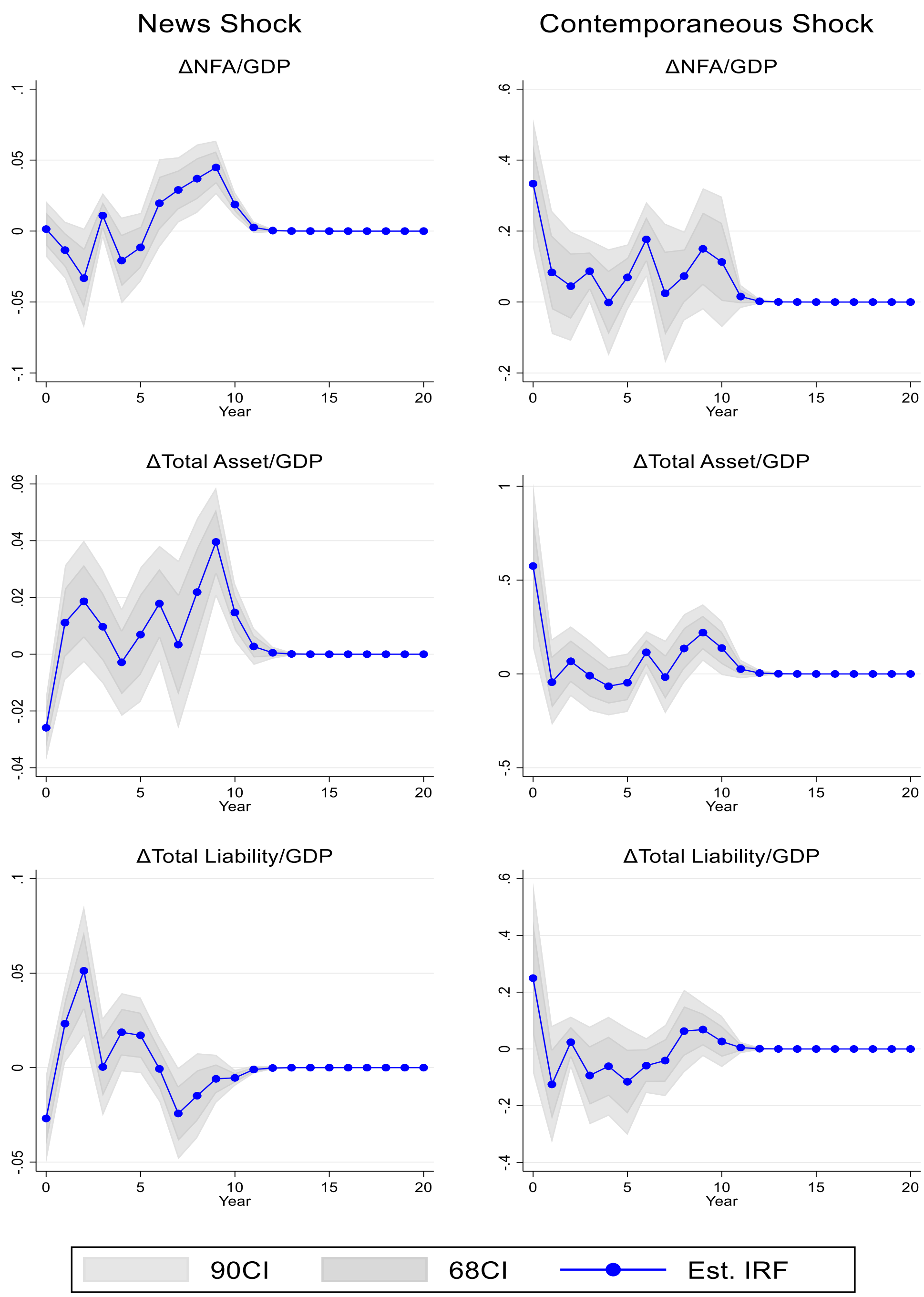

Figure I: Impact of Giant Oil Discoveries and Contemporaneous Oil Revenue Shocks on Changes in Net Foreign Assets and Total Foreign Assets and Liabilities

Note: The left column presents the impulse response of an oil discovery with NPV equal to 1% of GDP, and the right column displays the impulse response of oil net export revenue shock equal to 1% of GDP. The line with circles indicates point estimates, and the gray areas are 90% and 68% confidence intervals. The vertical axis shows percentage changes.

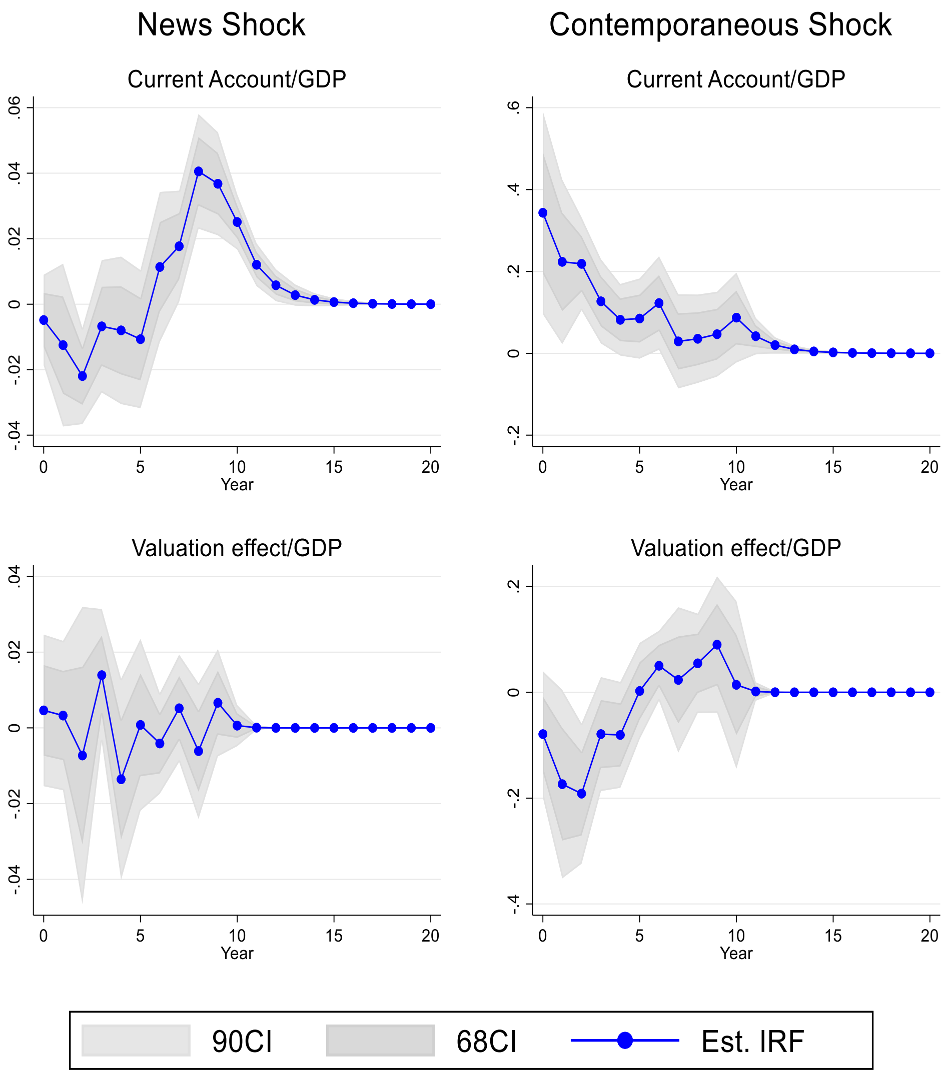

Figure II: Impact of Giant Oil Discoveries and Contemporaneous Oil Revenue Shocks on Current Account and Valuation Effects

Note: The left column presents the impulse response of an oil discovery with NPV equal to 1% of GDP, and the right column displays the impulse response of oil net export revenue shock equal to 1% of GDP. The line with circles indicates point estimates, and the gray areas are 90% and 68% confidence intervals. The vertical axis shows percentage changes.

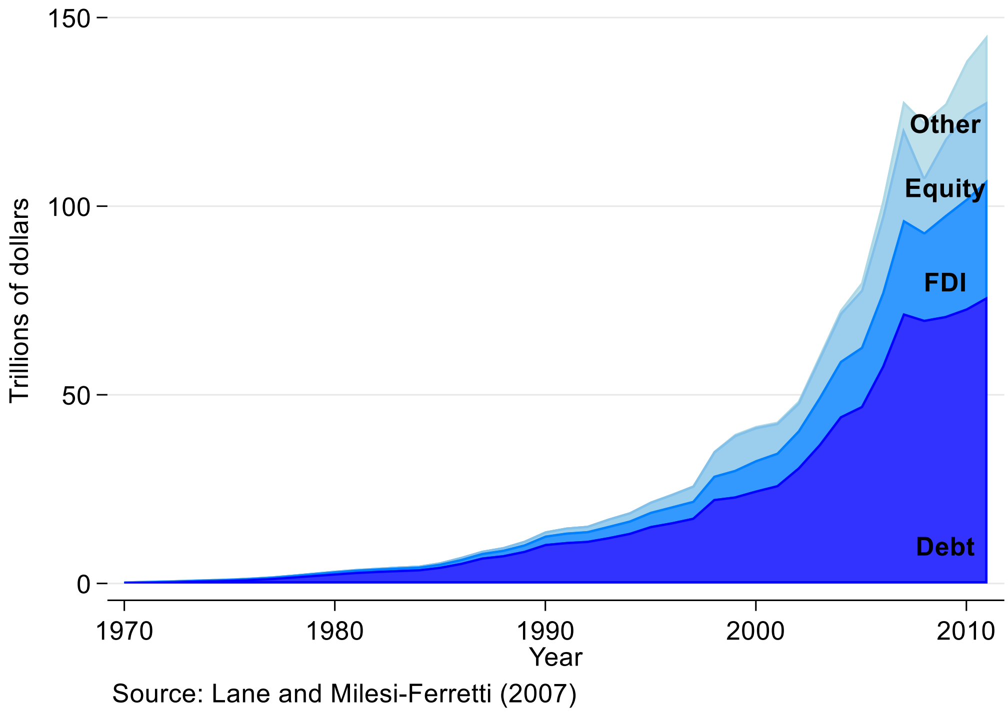

Figure III: Evolution of World Financial Liabilities (1970–2011)

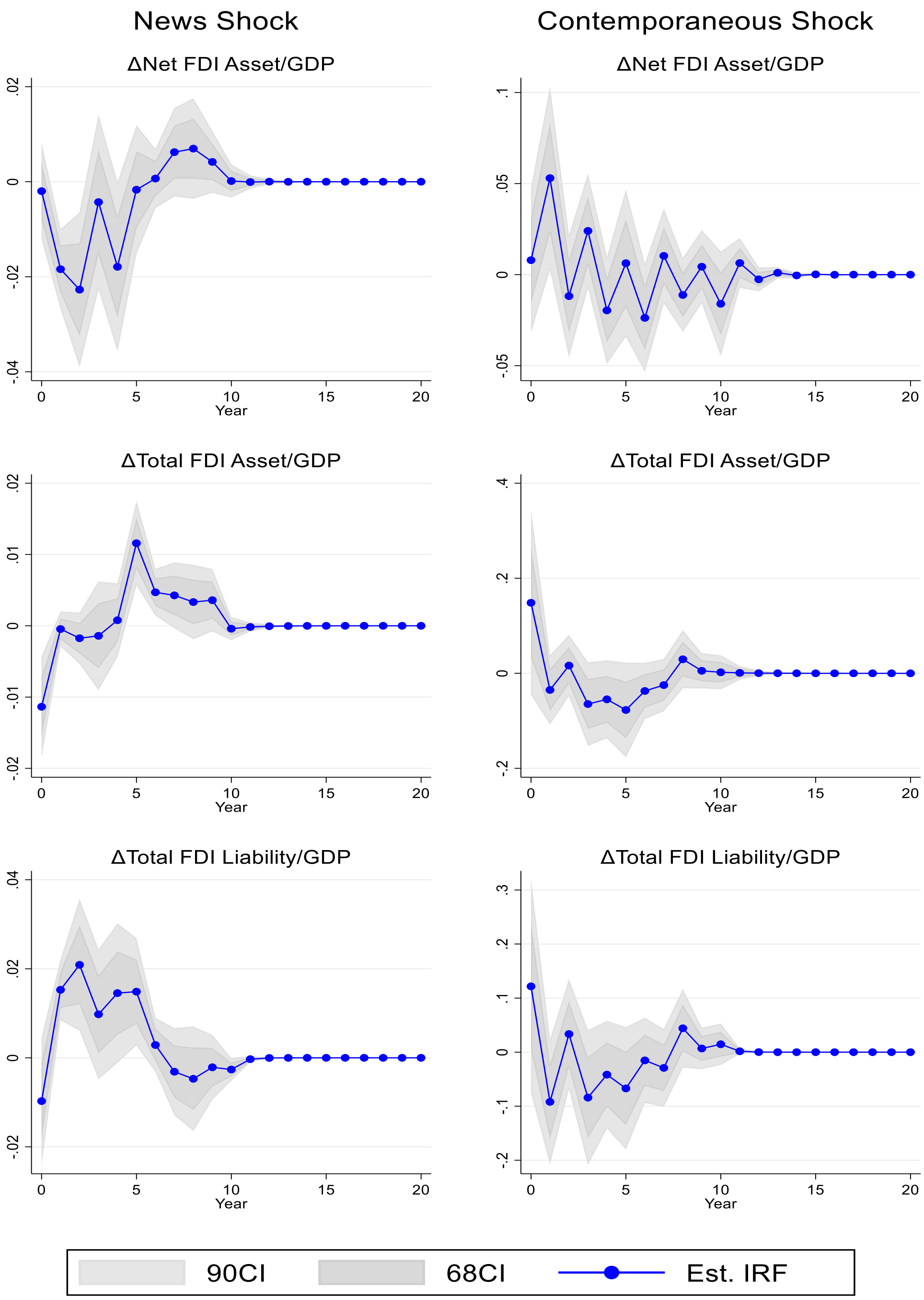

Figure IV: Impact of Giant Oil Discoveries and Contemporaneous Oil Revenue Shocks on Changes in FDI Assets and Liabilities

Note: The left column presents the impulse response of an oil discovery with NPV equal to 1% of GDP, and the right column displays the impulse response of oil net export revenue shock equal to 1% of GDP. The line with circles indicates point estimates, and the gray areas are 90% and 68% confidence intervals. The vertical axis shows percentage changes.

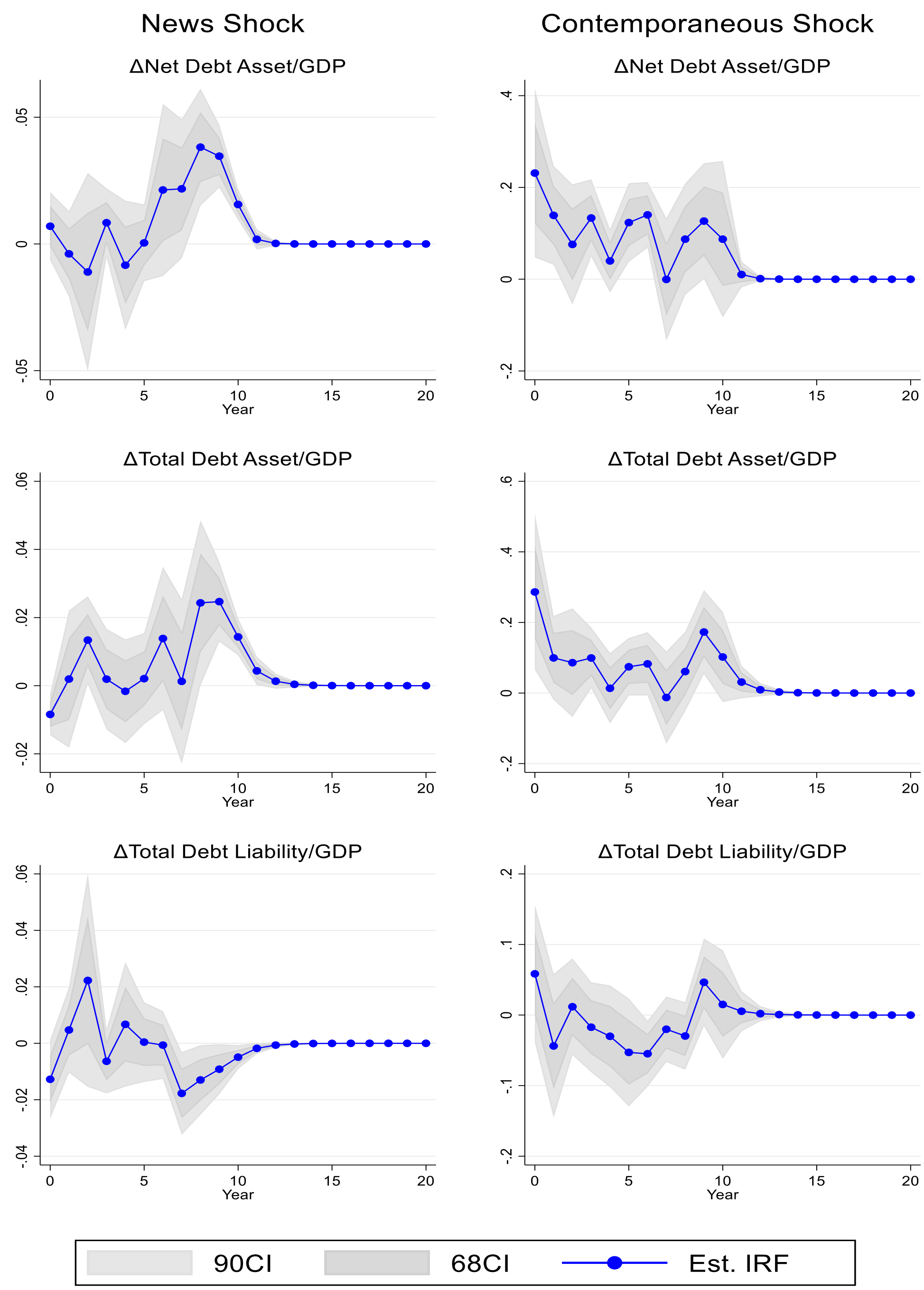

Figure V: Impact of Giant Oil Discoveries and Contemporaneous Oil Revenue Shocks on Changes in Foreign Debt Assets and Liabilities

Note: The left column presents the impulse response of an oil discovery with NPV equal to 1% of GDP, and the right column displays the impulse response of oil net export revenue shock equal to 1% of GDP. The line with circles indicates point estimates, and the gray areas are 90% and 68% confidence intervals. The vertical axis shows percentage changes.

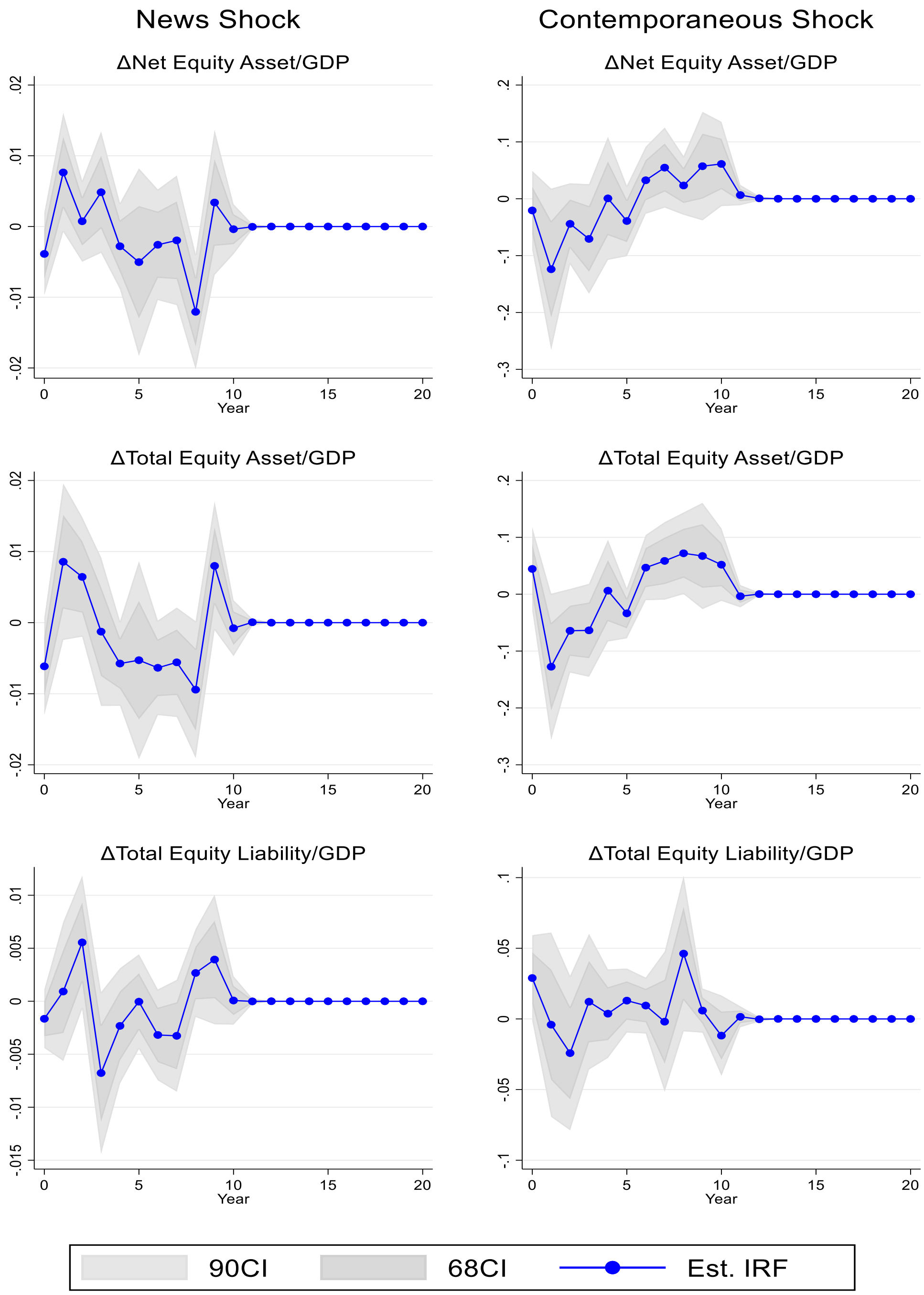

Figure VI: Impact of Giant Oil Discoveries and Contemporaneous Oil Revenue Shocks on Changes in Foreign Equity Assets and Liabilities

Note: The left column presents the impulse response of an oil discovery with NPV equal to 1% of GDP, and the right column displays the impulse response of oil net export revenue shock equal to 1% of GDP. The line with circles indicates point estimates, and the gray areas are 90% and 68% confidence intervals. The vertical axis shows percentage changes.

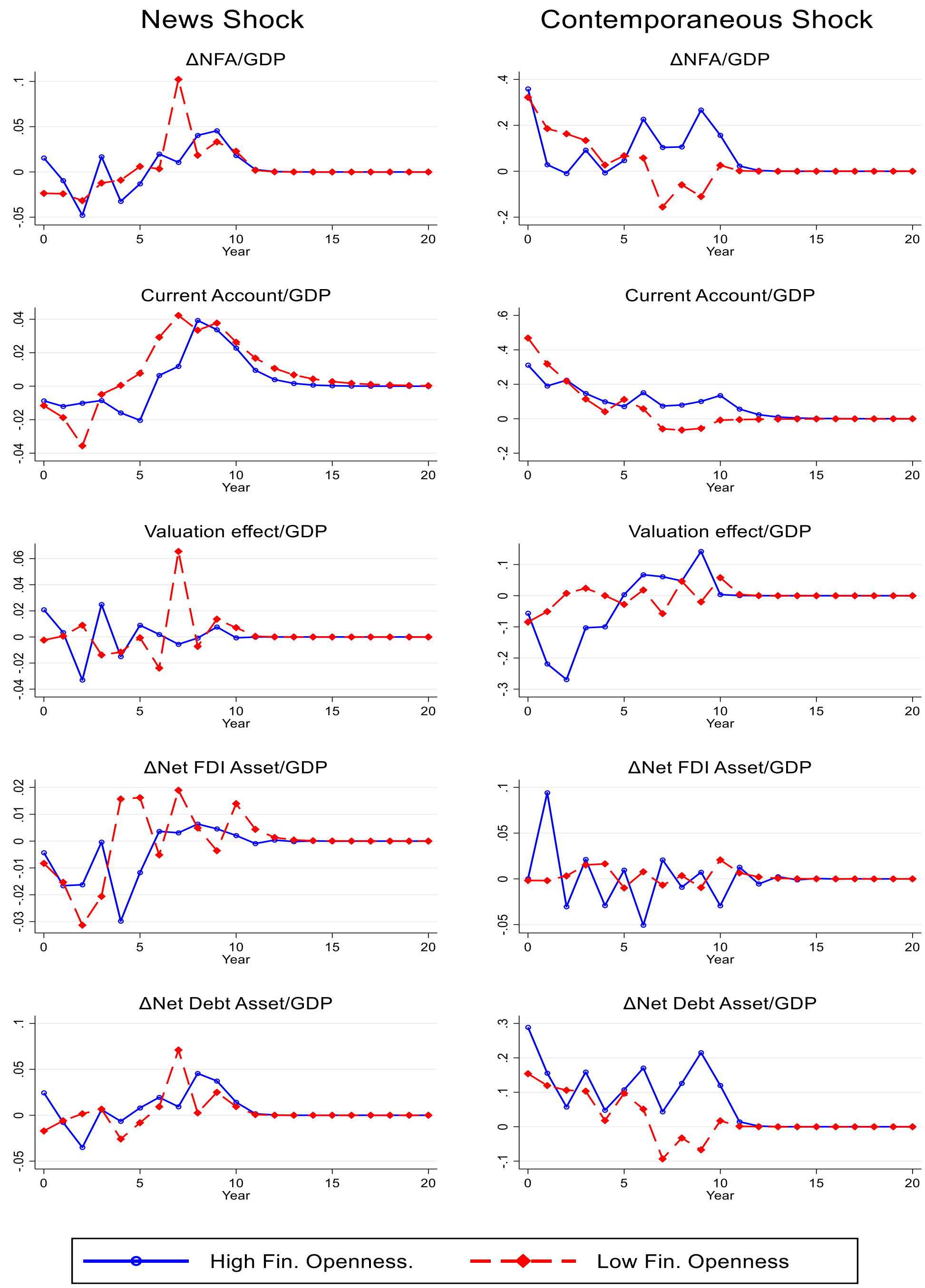

Figure VII: Financial Openness

Note: The figure presents the impulse responses of an oil discovery with NPV equal to 1% of GDP in the left column and oil net export revenue shock equal to 1% of GDP in the right column for countries with high and low financial openness, respectively. The vertical axis shows percentage changes.

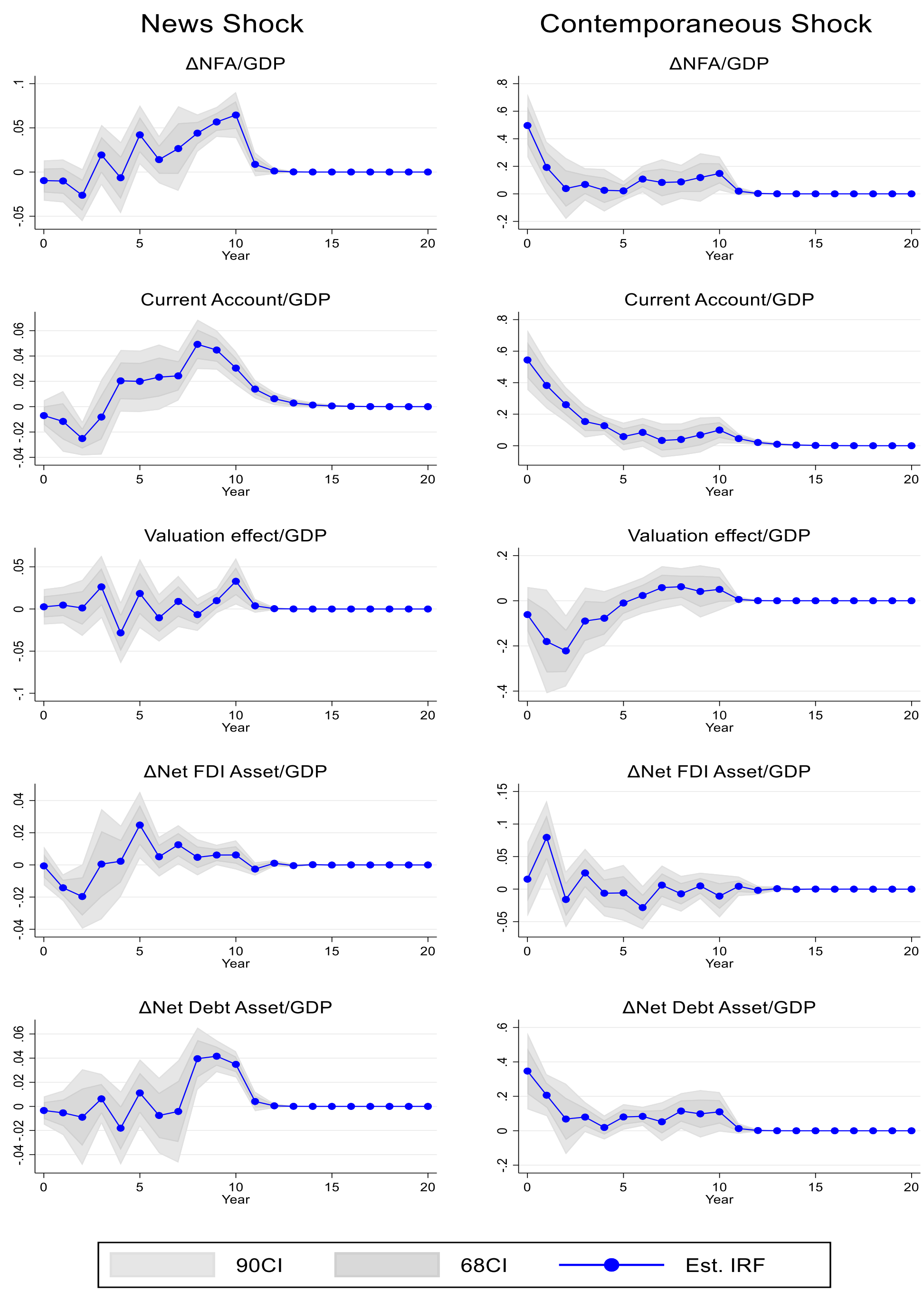

Figure VIII: Selected Giant Oil Discoveries and Unanticipated Oil Revenue Shocks

Note: The left column presents the impulse response of an oil discovery with its NPV equal to 1% of GDP, which does not have discoveries in the past three years, and the right column displays the impulse response of an oil net export revenue shock equal to 1% of GDP, where the oil net export revenue shock is measured as the residual from a panel AR(3) regression including country- and year-fixed effects, and a dummy variable indicating whether a giant oil discovery occurred in the past 10 years. The line with circles indicates point estimates, and the gray areas are 90% and 68% confidence intervals. The vertical axis shows percentage changes.