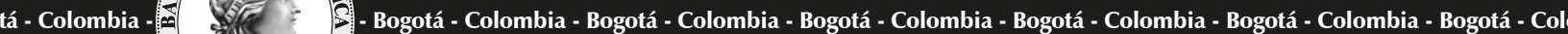


By: Neville Francis
Sergio Restrepo-Ángel

Borradores de ECONOMÍA



Sectoral and aggregate response to oil price shocks in the Colombian economy: SVAR and Local Projections approach

Neville Francis*
Sergio Restrepo-Ángel†

The opinions contained in this document are the sole responsibility of the authors and do not commit Banco de la República or its Board of Directors

Abstract

We employ Structural Vector Autoregressive (SVAR) and Jordà's (2005) Local Projection approaches to analyze the impact of a shock to international oil prices on the aggregate economy and three sectoral activities in Colombia: Agriculture, Mining and Industry. As an oil producer and exporter, this analysis is relevant due to the importance of the oil sector for Colombia's economy. Using data from 2000:Q1 to 2017:Q3, our results show that a positive shock to the price of oil increases Gross Domestic Product, lowers risk perception, appreciates the exchange rate, and leads to the adoption of contractionary monetary policy. An inflation-targeting scheme with flexible exchange rate makes both inflation and Foreign Direct Investment (FDI) non-responsive to the shock. Results at the sectoral level are mixed. Agriculture's FDI, production and Producer Price Index (PPI) are unaffected by the shock. Industry's production falls between the second and fifth quarters after the shock, with no significant responses in its PPI and FDI. Finally, the FDI and PPI respond positively in the Mining sector.

Keywords: monetary policy, oil prices, local projections, asymmetries.

JEL Classification: C32, C50, E52

*Department of Economics, University of North Carolina, Gardner Hall CB# 3305, Chapel Hill, NC 27599, e-mail: nrfranci@email.unc.edu

†Expert Economist, Monetary Policy and Economic Information Department, Banco de la República, Carrera 7 No. 14 -78 piso 12, Bogotá, Colombia, e-mail: srestran@banrep.gov.co

Respuesta agregada y sectorial de Colombia a choques en precios del petróleo: una aproximación SVAR y de proyecciones locales

Neville Francis*
Sergio Restrepo-Angel †

Las opiniones contenidas en el presente documento son responsabilidad exclusiva de los autores y no comprometen al Banco de la República ni a su Junta Directiva

Abstract

Usando Vectores Autorregresivos Estructurales (SVAR) y proyecciones locales (Jordà's (2005)) analizamos el impacto de choques temporales no anticipados en los precios del petróleo sobre el agregado de la economía y tres sectores: agricultura, minería e industria. Dada su condición exportadora de petróleo, el presente análisis cobra especial importancia en Colombia. Usando datos desde 2000:T1 a 2017:T3, los resultados muestran que un choque positivo al precio del petróleo incrementa el Producto Interno Bruto (PIB), disminuye la percepción de riesgo internacional, aprecia la tasa de cambio e induce la adopción de una política monetaria contractiva. El esquema de inflación objetivo con tipo de cambio flexible hace que tanto la inflación como la inversión extranjera directa (IED) no respondan de manera significativa al choque. A nivel sectorial se presentan resultados mixtos. El sector agrícola no presenta impactos significativos en IED, PIB y en los precios al productor (IPP). En el sector industrial, el PIB disminuye entre el segundo y el quinto trimestre luego de recibir el choque, con respuestas no significativas en el IPP e IED. Finalmente, en el sector minero tanto la IED como el IPP responden de manera positiva.

Palabras clave: política monetaria, precios del petróleo, proyecciones locales, asimetrías.

Clasificación JEL: C32, C50, E52

*Departamento de economía, University of North Carolina, Gardner Hall CB# 3305, Chapel Hill, NC 27599, e-mail: nrfranci@email.unc.edu

†Profesional Experto, Subgerencia Política Monetaria e Información Económica, Banco de la República, Carrera 7 No. 14 -78 piso 12, Bogotá, Colombia, e-mail: srestran@banrep.gov.co

1 Introduction

The effects of exogenous shocks to oil prices have been heavily scrutinized, as oil prices have been subject to frequent fluctuations in recent decades. Against this backdrop, a plethora of studies have emerged examining the nature and magnitude of the effects of oil price changes on economies around the world. While the effects of oil prices (and oil price uncertainties) on aggregate economic activities are well documented (Kellogg, 2010; Elder and Serletis, 2010; Ferderer 1996; Rafiq et al., 2009), few papers have examined the effects of oil price changes on sectoral activities.

According to Toro et.al (2015), favorable terms of trade in recent years, as a result of high oil (and other commodity) prices, allowed Colombia to increase (since 2004) its growth rate and achieve rapid recovery from the effects of the world financial crisis in 2009. In the case of oil, its high price coincided with significant expansion of its production levels, which led the oil sector to become more prominent in many aspects of the Colombian economy. For example, of total exports between 2010 and 2013, 51% corresponded to external sales of oil and its derivatives, while about 37% of total foreign direct investment (FDI) flows went to the oil sector. Oil activity contributed on average 15.6% between 2011 and 2014 to national government income, while oil royalties increased its share of revenues for Colombian state regions from a level of 7.5% in 2005 to 18.7% in 2012. At the same time, the share of the oil sector in total gross domestic product (GDP) increased from 3.9% to 5.2% between 2005 and 2014.

From the second half of 2014 the Colombian economy began to be negatively affected by the sharp drop in the price of oil, which resulted in a significant reduction of the terms of trade. This was characterized as surprising, accelerating and of a considerable magnitude (Toro et.al (2015)). Additionally, the shock was persistent and spread over several years. The decline in the price of oil affected the economy in different ways. There was a decline in the terms of trade, a reduction in national income, lower investment, deterioration of the external balance and fiscal accounts, as well as less dynamic FDI inflows.¹

The economic sectors, agriculture, mining and industry use oil to produce output and as such oil price fluctuations will affect these sectors. Numerous studies have reported that a surge in crude oil prices significantly affects economic growth depending on whether the country is an oil producer and exporter or net importer (Bolaji and Bolaji, 2010; Dhuyvetter and Kastens, 2005; Alper and Torul, 2009; Rodriguez and Sanchez, 2004). Agricultural machines, such as tractors and croppers, use oil as power generator in the production, and transportation of products from the rural areas to cities and municipalities where most of the consumption takes place.²

Oil makes up a significant fraction of production cost in the Industrial. For example, Bolaji and Bolaji, 2010 showed that high oil prices in Nigeria inflated the cost and quantity of raw materials

¹See http://www.banrep.gov.co/sites/default/files/publicaciones/archivos/isi_jun_2015.pdf

² For the United States Dhuyvetter and Kastens (2005) found that higher oil prices can trigger higher machinery costs that agricultural producers have to bear.

purchased mainly for manufacturers, as oil price affects the shipping costs of raw materials purchased for production.

Finally, oil is a product from the Mining sector and so an increase in its price incentivizes an increase in oil production but at the same time it will also see an increase in production costs through the Producer Price Index (PPI). According to Energy and Mines portal,³ in Brazil diesel accounts for roughly 20% of operating costs for mining companies, so energy costs can represent a sizable chunk of the operating expenses for any mine. For Colombia we do not know the exact share but, according to the aforementioned reports, it should range between 15 to 25 percent of production costs. An increase in the oil price should attract FDI as investments in this sector will be perceived as more profitable.

We examine the effect of oil price shocks on FDI inflows, GDP, Inflation, Policy Rate, Emerging Market Bond Index (EMBI+ Colombia) and the US dollar exchange rate of the Colombian economy. We explore how an unexpected rise in oil price impacts agriculture, industry and mining sectors. We first estimate a SVAR using aggregate time series for the Colombian economy. The purpose of this exercise is twofold: to analyze the aggregate impact of a shock to oil prices, and to identify the structural oil price shock. Once the innovation in oil prices is identified, we use Jordà's (2005) local projection method to estimate impulse responses of each sector (mining, industry and agriculture) to this shock. An apparent interest in this issue derives from Colombia's development journey based on energy-dependent industrial growth over the last few decades, characterized by its more volatile records in the recent past. In particular, we attempt to delve into the effects of oil price uncertainties in a disaggregated framework, to various sectors of the Colombian economy, with an aim to further understand the sectoral growth patterns and contribute to the policy environment.

We find that a positive shock to oil prices increases GDP and the monetary policy rate. As expected, we see a drop in Colombia's risk perception through the EMBI+ and an appreciation of the US dollar exchange rate. Central Bank's effort in keeping inflation stable is apparent as there is no significant effect on prices. Also, due to mix effects on the various sectors in the economy, there is no significant response in FDI.

At the sectoral level, Agriculture is not affected by the shock. Industry sees its production falling between the second and fifth quarters after the shock. Neither its PPI nor FDI significantly responds to oil price shocks. In Mining, FDI and PPI increase, but production does not respond significantly. The non-response of production may be due to costs being highly dependent on oil, and thus, an unexpected surge in the price dampens production through higher costs. Also, oil production is a relatively sticky variable and should not respond immediately to a temporary unexpected oil price shock. In every model we see a significant contractionary monetary policy response, an appreciation of the exchange rate and a decrease in country's risk perception after a positive innovation to oil prices.

The rest of the paper is ordered as follows: Section 2 provides a review of the literature. Section

³<http://energyandmines.com/wp-content/uploads/2015/02/EM-PDF-Oil-Article-2-web.pdf>

3 describes the data. Section 4 estimates the SVAR and Jordà's (2005) Local Projection methods and gives an explanation of the ordering of the variables used in the model. Section 5 presents the impulse-responses and analyzes the results. Section 6 offers concluding comments.

2 Literature review

Many researchers have investigated the effects of oil price changes on economic dynamics. Various methodologies have been employed with Vector Autoregression Modeling the most popular approach to examine the effects of oil price (see Alper and Torul 2009, Rodriguez and Sanchez 2004, Petersen et al., 1994, and Melo-Becerra 2016). Melo-Becerra (2016) applied a time-varying parameter VAR methodology (VAR-TVP), assuming the relationship between prices and/or oil production with macroeconomic variables evolved dynamically. Results show that there are different stochastic volatility patterns to the variables and positive shocks to oil price did not have significant effects on the real exchange rate.

In a descriptive analysis of the recent oil shock Toro et al (2015) investigated its determinants and implications for the Colombian economy. Falling oil prices led to a deterioration of the country's terms of trade and, thus, its national income. Other key variables affected are the current account, the exchange rate, public finance, market confidence and the country risk premium. As a result, a significant economic slowdown took place. The economic policy response has been coherent, with a sound institutional framework previously established, which has encouraged an orderly adjustment to the new external circumstances. Among the key elements of such framework is an inflation-targeting scheme with flexible exchange rate, a fiscal rule for the central Government, and a macro-prudential policy aimed at preserving financial stability.

Alper and Torul (2009) investigates the relationship between oil prices and manufacturing sub-sectors for Turkey and found that an oil price increase does not impact said sectors. However, it influences the real production growth rate of several manufacturing sub-sectors such as wood and wood products, furniture, chemical and chemical products, rubber and plastic products, electrical machinery and communication apparatus. Rodriguez and Sanchez (2004) finds that oil prices have heterogenous effects on real economic activities of OECD countries. For example, in the United Kingdom, a rise in oil prices negatively affects economic growth, while having positive effects for Norway.

Petersen et al. (1994) examines the effects of oil on the construction sector in the Texas economy during 1970s and 1980s. Results show that oil price fluctuations play an important role as they affect investor's expectations of Texas Gross State Product. In Tunisia, Bouzid (2012) shows that a change in real crude oil prices negatively influences real GDP. He suggests that rise in oil prices can cause economic growth to stagnate since it affects daily consumption pattern of households. Using a similar model, a negative effect of oil prices was also found by Syed (2010) for Pakistan.

Several studies have investigated the uncertainty–investment nexus for developing countries, focusing on the linkage between macroeconomic uncertainty and aggregate investment (Serven, 2003; Pradhan

et al., 2004; Ang, 2010; Fatima and Waheed, 2011; Ibrahim, 2011; Ahmed and Wadud, 2011 and Ibrahim and Ahmed, 2014). Rafiq et al., (2009) finds that oil price volatility has significant impact on unemployment and investment, over the period 1993 to 2006. Rafiq and Salim (2011) shows that there exists unidirectional short- and long-run causality running from energy consumption to GDP for China, uni-directional short-run causality from output to energy consumption for India, whilst bidirectional short-run causality for Thailand. More recently, Ibrahim and Ahmed (2014) investigates the relationship between aggregate investment and oil volatility and its permanent and transitory components for a developing country, Malaysia. SVAR estimates show that the real effects of permanent oil volatility tend to be strong for Malaysia.

While these studies differ in terms of the countries covered (developed versus developing countries), data structure (time series versus panel data), time periods, and the measurement and sources of uncertainty, they also provide mixed evidence of the effects of oil price changes on economic activities in developed and developing economies. However, these studies do provide a fairly consistent view that oil price uncertainty depresses real investment and output (Cardenas et. al 2018).

3 Data

We collect quarterly data from 2000Q1 to 2017Q3. The data vector for all variables is $\{OP, FDI, GDP, INF, R, EMBI, XR\}$. where OP is the annual growth rate of West Texas Intermediate (WTI) oil price per barrel in US dollars, FDI is the quarterly annual log difference of gross foreign investment inflows to Colombia, in US dollars. GDP is the quarterly real seasonally adjusted GDP annual log difference, INF is the quarterly annual growth rate of the Consumer Price index (inflation). For the sectoral models, we use Gross Domestic Product Quarterly by branches of economic activity and the quarterly annual growth rate of the Producer Price index, both published by Colombia's National Statistics Institute *Departamento Administrativo Nacional de Estadística (DANE)*. R is the Colombian Central Bank's policy rate.⁴ $EMBI$ is the quarterly average of the JP Morgan's Emerging Market Bond Index for Colombia. XR is the quarterly annual log difference of the bilateral nominal exchange rate between U.S. and Colombia (measured in COP/USD).

Data sources on GDP and INF were obtained from DANE, while FDI , XR and R were collected from Banco de la Republica's website⁵ (Colombia's Central Bank). WTI price was collected from the World Bank Commodity Prices Indexes. $EMBI$ was obtained from Bloomberg. Figures 1, 2, 3 and 4 show the plots of all the series used in the models.

Oil prices increased dramatically during 2004–2006. With the biggest increase in 2008 when it reached a maximum of USD 145 per barrel (WTI) in July. Industry experts initially attributed these price increases to fundamental factors such as the rise in global demand, but also because of disruptions in the supply of oil (Bhar & Malliaris 2011). By the beginning of 2009, during the most critical moment

⁴Measured as the rate in force at the end of each quarter

⁵<http://www.banrep.gov.co>

of the crisis, it went down to 34 USD (red vertical line in oil graph in Figure 1). The crash of oil prices during 2009 was due to rapid deleveraging by speculative funds, rapid closing of oil positions, and drying up of liquidity (Bhar & Malliaris 2011). The policy rate in Colombia has had a countercyclical behavior, with a marked difference in mean before and after the financial crisis. The rapid reaction of the monetary authority, among several other factors described later on, during the international financial crisis (which dropped the policy rate from 9.5% to 5% between December/08 and June/09) led Colombia to be one of the few countries that did not experience negative GDP growth in the aftermath of the financial crisis.

Monetary policy decisions were based on a persistent and sharp decline in inflation; result of weak internal and external demand, lower expectations of inflation and a fall in international commodity prices (Report of the Board of Directors to the Congress, March 2010).⁶ In general, the EMBI+ of Colombia has seen steady declines over our coverage period, with two exceptions. The first, from mid-2007 to December 2008, which was due to Colombia not having investment grade and an economy growing at historically high rates, way beyond its potential growth (Inflation Report, June 2008).⁷ The second, from mid-2014 to mid-2015, a period in which oil prices dropped drastically. This reduced the value of exports and the inflow of capital, sharply depreciating the exchange rate.

Agricultural GDP has historically oscillated between -1% and 9% (Figure 2), registering its lowest growth rates in the aftermath of the financial crisis of 2008. Industrial GDP has a similar path to aggregate GDP, with the difference that it registered negative growth rates in at least one quarter in every year after the world financial crisis (with the exception of 2016).

In the mining sector we see two distinct patterns to GDP growth rates (Figure 2). A steady positive trend from 2000 to mid-2011 (despite having negative growth until 2003) and a negative, steeper trend since mid-2011. The latter behavior is explained by a weaker external demand along with lower commodity prices (World Economic Outlook, October 2015),⁸ especially oil, coal and nickel (Colombia's main commodity exports).

Figure 3 shows the plots for FDI (total, agriculture, industry and mining). During 2005:Q4 based on the Quarterly Report of Balance of Payments of Colombia,⁹ there were three transactions of firms belonging to Industry and Mining sectors that accounted for 84% of total *FDI* inflows to Colombia in that quarter.¹⁰ The opposite happened in 2006:Q4 where two unspecified transactions from firms belonging to Industry and Mining sectors atypically reduced *FDI* inflows during that period. For inflation, we controlled for outlier during the aftermath of the global financial crisis in 2009:Q2; a period that was characterized by sharply declining annual inflation, explained mostly by the slowdown

⁶http://www.banrep.gov.co/sites/default/files/publicaciones/archivos/ijd_mar_2010.pdf

⁷http://www.banrep.gov.co/sites/default/files/publicaciones/archivos/informe_jun_08.pdf

⁸http://www.imf.org/~media/Websites/IMF/imported-flagship-issues/external/pubs/ft/weo/2015/02/pdf/_c2pdf.ashx

⁹See <http://www.banrep.gov.co/informe-comportamiento-balanza-pagos>

¹⁰i) Selling operation of the Colombian brewer Bavaria to the international brewer SABMiller, ii) Operation corresponding to the sale of shares of Compañía Colombiana de Tabaco SA to the multinational Phillip Morris, and iii) the sale of shares of companies producing construction materials to foreign investors.

in food prices and weak domestic demand.¹¹

Inflation in Colombia has had a negative trend since the country adopted the inflation-targeting regime in 2000 (Figure 4). Since then, there has been only two periods of out-of-target inflation. The first one in 2007, year in which the Colombian economy grew at the highest rate in 30 years (6,85%), way higher than its potential GDP growth rate. This gave clear signs of an overheated economy, which showed up in inflation rates of around 6%. According to Gonzalez et. al (2013), in Colombia there is a strong positive correlation between the output gap¹² measures and the core inflation, defined as the cpi less food items inflation.¹³ Moreover, the output gap precedes the movements in the core inflation to some extent.

The second period in which inflation was above the target was from 2014 to mid-2016 (Figure 4). The increase in inflation during this period was mainly explained by the partial transfer of the depreciation of the nominal exchange rate to consumer prices and raw materials for production.¹⁴ Also, to the sharp increase in food prices due to El Niño weather phenomenon.¹⁵

Producer Price Index for Agriculture has had a steady mean of 4% and an increased volatility since 2008 (Figure 4). According to DANE, the big drop in 2012 was due to a fall in Coffee prices (-42.02%), Oil oils (-10.60%), and Potatoes (-41.33%).¹⁶ The sharp increase during 2014 was due to the recovery in prices of the same goods that made the index fell in 2012. Industry had a declining trend in its PPI (similar to CPI) during all the period analyzed but an almost constant volatility. In Mining we point out the high volatility in prices during the aftermath of the global financial crisis (2009 and 2010) and a posterior reduction in both volatility and trend from 2010 onwards.

4 Structural VAR and Local Projections modelling

Our premise is that oil price shocks arise from the macroeconomy. As such we identify oil shocks by imposing restrictions on the economy-wide VAR. We later feed these shocks into sectoral regressions to gauge their effects on select sectors.

4.1 Structural VAR

We estimate a Structural VAR using aggregate series ($OP, FDI, GDP, INF, R, EMBI, XR$) for the economy. In order to identify the oil price shocks that affected Colombia during the period analyzed.

¹¹See Inflation Report for 2009:Q2: http://www.banrep.gov.co/sites/default/files/publicaciones/archivos/junio_13.pdf

¹²According to the IMF, the output gap is an economic measure of the difference between the actual output of an economy and its potential output. Potential output is the maximum amount of goods and services an economy can turn out when it is most efficient—that is, at full capacity.

¹³Core inflation gap is defined as the current level of inflation less the target.

¹⁴See Inflation Report for 2015:Q4: http://www.banrep.gov.co/sites/default/files/publicaciones/archivos/isi_dic_2015.pdf

¹⁵According to the National Oceanic and Atmospheric Administration, the term El Niño refers to the large-scale ocean-atmosphere climate interaction linked to a periodic warming in sea surface temperatures across the central and east-central Equatorial Pacific.

¹⁶https://www.dane.gov.co/files/investigaciones/boletines/ipp/cp_ipp_dic12.pdf

First, assume that the Colombian economy can be described by:

$$A(L)y_t = \varepsilon_t \quad (1)$$

Such that $A(L) = A_0 + A^0(L)$, which implies:

$$A_0 y_t = A^0(L)y_t + \varepsilon_t \quad (2)$$

where y_t is a $n \times 1$ vector of endogenous variables, A_0 is an $n \times n$ matrix that specifies the contemporaneous relationships between variables, $A^0(L)$ is a matrix polynomial in the lag operator L without the contemporaneous matrix included, and ε_t is an $n \times 1$ structural disturbance vector. ε_t is serially uncorrelated and $var(\varepsilon_t) = \Lambda$ where Λ is a diagonal matrix whose diagonal elements are the variances of the structural disturbances. This SVAR cannot be observed directly; thus, to be able to extract the coefficients of the structural model, we estimate a reduced form VAR and rotate into structural form:

$$y_t = B(L)y_t + \mu_t \quad (3)$$

where $B(L) = A_0^{-1}A^0(L)$ is a matrix polynomial in lag operator L and $\mu_t = A_0^{-1}\varepsilon_t$ is a $n \times 1$ vector of the reduced form errors. These errors are typically serially correlated with $var(\mu_t) = \Sigma$. The structural disturbances and reduced form errors are related through

$$\varepsilon_t = A_0 \mu_t \quad (4)$$

implying that

$$\Sigma = A_0^{-1} \Lambda A_0^{1/T} \quad (5)$$

We impose several “exclusion” restrictions—that is, setting certain contemporaneous relationships in the A_0 matrix to zero. For this reason, it is necessary that restrictions have an a priori economic logic and theoretical support.

In our case, the exact ordering of the variable follows $\{OP, FDI, GDP, INF, R, EMBI, XR\}$. This implies that the oil price is the most exogenous of all the variables, and Exchange Rate the least exogenous. We impose the following structure to the A_0 matrix based on assumptions below:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & a_{32} & 1 & 0 & 0 & 0 & 0 \\ 0 & a_{42} & a_{43} & 1 & 0 & 0 & 0 \\ 0 & 0 & a_{53} & a_{54} & 1 & 0 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 \end{bmatrix} \begin{bmatrix} \mu_{op} \\ \mu_{fdi} \\ \mu_{gdp} \\ \mu_{inf} \\ \mu_r \\ \mu_{embi} \\ \mu_{xr} \end{bmatrix} = \begin{bmatrix} \varepsilon_{op} \\ \varepsilon_{fdi} \\ \varepsilon_{gdp} \\ \varepsilon_{inf} \\ \varepsilon_r \\ \varepsilon_{embi} \\ \varepsilon_{xr} \end{bmatrix} \quad (6)$$

We start the recursive ordering with the oil price. Colombia is a minor oil producer compared to

OPEC countries and does not have direct influence on international oil prices (Toro et. al (2015); Hamann et. al (2015)). FDI is ordered second as it is affected by oil price but assumed not affected contemporaneously by the other variables. Colombian GDP, inflation and monetary policy rate are contemporaneously unaffected by oil price shocks as it takes some time for markets to adjust prices and interest rates. Also, we allow FDI shocks to have contemporaneous effect on the policy rate. Having the EMBI and the nominal exchange rate react contemporaneously to all other variables is in line with the literature (Cushman and Zha 1997; Kim 2001); given that the exchange rate is a forward-looking asset that quickly captures changes in all other variables.¹⁷

Given that we have sharp increases or decreases on certain variables, we controlled for dates with more than three standard deviations.

4.2 Local Projections

We use Jordà's (2005) local projection method to estimate impulse responses of the sectoral variables to the identified structural shock ε_{op} in section 4.1. We have too few observations to estimate one complete VAR: i.e., to append sectoral VAR (Agriculture, Mining or Industry) onto the aggregate VAR [Agg VAR, Sector VAR]. Hence we resort to Local Projections.¹⁸ Also given that the oil shock is derived solely from the aggregate VAR, local projection is well suited for uncovering sectoral dynamics.

According to Jordà (2005), the advantages of local projections are numerous: they can be estimated by simple least squares; they provide appropriate inference (individual or joint) that does not require asymptotic delta-method approximations or numerical techniques for its calculation; they are robust to misspecification of the data generating process (DGP); and they easily accommodate experimentation with highly nonlinear specifications that are often impractical or infeasible in a multivariate context. Since local projections can be estimated by univariate equation methods, they can be easily calculated with available standard regression packages and thus become a natural alternative to estimating impulse responses from VARs.

Auerbach and Gorodnichenko (2013) used this technique to estimate state-dependent fiscal models. More recently, Ramey & Zubairy (2018) used it to investigate whether U.S. government spending multipliers are higher during periods of economic slack or during periods when interest rates are near the zero lower bound. The Jordà method simply requires estimation of a series of regressions for each horizon h for each variable. Following the notation in Ramey & Zubairy (2018), the linear model looks as follows:

$$x_{t+h} = \alpha_h + \psi_h(L)z_{t-1} + \beta_h shock_t + \varepsilon_{t+h} \text{ for } h = 0, 1, 2, \dots, 10 \quad (7)$$

¹⁷Given that we have sharp increases or decreases on certain variables, we controlled for dates with more than three standard deviations.

¹⁸ This approach has been used as a flexible alternative that does not impose the dynamic restrictions embedded in vector autoregressive (autoregressive distributed lag) specifications.

x is the variable of interest among $\{OP, FDI, GDP, INF, R, EMBI, XR\}$, z is a vector of control variables, $\psi_h(L)$ is a polynomial in the lag operator, and the shock is the identified oil price shock ε_{op} from section 4.1. Our vector of baseline control variables, z , contains lags of Oil Price changes, FDI , Production by sector (which we call GDP), PPI , Policy Rate, EMBI and Exchange Rate. FDI , GDP and PPI are the sector-specific variables and $\psi(L)$ is a polynomial of order 3. The coefficient β_h gives the response of x at time $t + h$ to the shock at time t . Thus, one constructs the impulse responses as a sequence of the β_h 's estimated in a series of single regressions for each horizon. This method stands in contrast to the standard method of estimating the parameters of the VAR for horizon $h = 0$ and then using them to iterate forward to construct the impulse response functions. The only complication associated with the Jordà method is the serial correlation in the error terms induced by the successive leading of the dependent variable. Thus, we use the Newey-West correction for our standard errors (Newey and West (1987)).

4.3 Testing for Asymmetric effects of Unanticipated Oil Price Shocks

A common view in the literature is that the effects of energy price shocks on macroeconomic aggregates are asymmetric. In particular, energy price increases are perceived to have larger effects than energy price decreases (Mork, 1989; Bernanke, Gertler and Watson, 1997; Hooker, 2002). This perception has been reinforced by empirical evidence that energy price increases¹⁹ have apparently large effects on the macro variables, whereas uncensored percent changes in energy prices tend to have smaller effects (see, e.g., Dotsey and Reid 1992; Davis and Haltiwanger 2002; Lee and Ni 2002; Jones, Leiby, and Paik 2004; Jiménez-Rodríguez and Sánchez 2005; Herrera 2008).

Kilian and Vigfusson (2009) showed that most of the asymmetric VAR models of the transmission of energy price shocks are misspecified, resulting in inconsistent parameter estimates, and that the implied impulse responses have been computed incorrectly. In this paper we use their approach to compute responses to oil price shocks that yield consistent estimates regardless of the degree of asymmetry for the Colombian economy.

Following Kilian and Vigfusson (2009), we estimate the following model for the SVAR with the aggregate variables:

$$oil_t = b_{10} + \sum_{i=1}^p b_{11,i} oil_{t-i} + \sum_{i=1}^p b_{12,i} y_{t-i} + \varepsilon_{1t} \quad (8)$$

$$y_t = b_{20} + \sum_{i=0}^p b_{21,i} oil_{t-i} + \sum_{i=1}^p b_{22,i} y_{t-i} + \sum_{i=0}^p g_{21,i} oil_{t-i}^+ + \varepsilon_{2,t} \quad (9)$$

¹⁹Obtained by censoring energy price changes to exclude all energy price decreases

Where oil_t^+ is defined as:

$$oil_t^+ = \begin{cases} oil_t & \text{if } oil_t > 0 \\ 0 & \text{if } oil_t \leq 0 \end{cases} \quad (10)$$

And y_t is the vector $\{FDI, GDP, INF, R, EMBI, XR\}$. $b_{10}, b_{11}, b_{12}, b_{20}, b_{21}, b_{22}, g_{21}$ are constants, ε_{1t} and ε_{2t} are mean zero i.i.d. Gaussian random variables with variances σ_1^2 and σ_2^2 , and $t = 1, \dots, T$.

Given estimates of these coefficients, one can calculate the dynamic responses to unanticipated positive and negative oil price changes.²⁰ As the OLS residuals of the model described by equations (8) and (9) are uncorrelated, it may be estimated by standard regression methods. Also, the advantage of the model described by equations (8), (9) and (10) is that the dynamic responses are consistently estimated regardless of whether the true data generating process is symmetric or asymmetric. This allows us to use it as well for the sectoral Local Projections models. For this, we adapt model (7) to include the censored variable oil_t^+ and estimate:

$$x_{t+h} = \alpha_h + \psi_h(L)z_{t-1} + \gamma_h oil_{t-1} + \varphi_h oil_{t-1}^+ + \beta_h shock_t + \varepsilon_{t+h} \text{ for } h = 0, 1, 2, \dots, 10 \quad (11)$$

Where again x is the variable of interest among $\{OP, FDI, GDP, INF, R, EMBI, XR\}$, z is a vector of control variables, $\psi_h(L)$ is a polynomial in the lag operator, and $shock$ is the identified oil price shock of the model described by equations (8) and (9). The vector of baseline control variables, z , contains lags of $\{OP, FDI, GDP, INF, R, EMBI, XR\}$ and $\psi(L)$ is a polynomial of order 3. The sign and significance of the parameter φ_h for $h = 0, 1, 2, \dots, 10$ will determine if there is evidence of symmetric or asymmetric effects of oil price shocks. In Section 5.3.2 results are presented.

5 Results

In this section, results from the aggregate SVAR specification and sectoral Local Projections will be presented. Subsection 5.3 shows both results including the test for asymmetric effects on oil price shocks. The results of subsections 5.1 and 5.2 will take the form of impulse responses showing the path of a variable's response to an unexpected shock to oil price in the system over time, which here will be 10 periods (quarters). Given that the SVAR estimated in Section 4.1 was built with the goal of identifying the series of oil price shocks to the Colombian economy, the impulse response functions to this particular shock will serve as the main avenue of analysis. The SVAR model has a lag order of one according to Schwarz Criterion lag-length criteria showed in Appendix B. Results of subsection 5.3 show the point estimates and the confidence interval of coefficient φ_h for $h = 0, 1, 2, \dots, 10$ of equation (11) for the sectoral Local Projection models.

²⁰If oil prices always have positive growth, this model would suffer from perfect collinearity. In our data, we observe both positive and negative variability.

5.1 Aggregate SVAR analysis

The first model to be estimated is the SVAR(1) with total aggregate variables for the economy. Figure 5 show the response of FDI , GDP , INF , R , $EMBI$, R and XR to an unexpected shock to OP .

An unexpected positive shock to the oil prices makes the GDP rise. This is not surprising as Colombia's Oil exports represents more than 50% of total exports and around 5% of total GDP. Thus, a rise in the price will provide incentives to increase oil production and hence, increase GDP. A rise in both production and exports in Colombian Oil industry would naturally make it more attractive to foreign investors, but apparently the mixed effects from other sectors make it, on the aggregate, not a significant influx of foreign direct investment towards Colombia. The more abundant US currency in the foreign exchange markets will make the Colombian Peso stronger, which is reflected in the appreciation of the nominal exchange rate. With respect to the sovereign risk perception, Beltrán (2015) analyzes the impact of a negative shock of the price of oil on the economy, focusing on the external financing premium channel or interest rate differential. On the one hand, he validates the negative and significant correlation between the price of oil and the interest rate differential (EMBI), while on the other, it obtains that the risk perception increase in the face of a contemporary negative impact on the price of oil, which is exactly what we observe in our model. Central Bank's effort in keeping inflation stable shows up as there is no significant effect on this variable. Lastly, there seems to be an accommodative monetary policy (increasing the Monetary Policy Rate), which according to the model is very effective.

The previous model was built with the goal of identifying the structural oil price shock (ε_{op}) that affected the Colombian economy. Figure 6 plots and analyzes this shock. This series of structural oil shocks that the Colombian economy faced between 2000:Q1 and 2017:Q3 is consistent with others found in the literature (Hamann 2015, Beltrán 2015, Toro et. al. 2015).

From 2007 to mid-2008, the WTI price hiked from 60 U.S. dollars per barrel to 140 U.S. dollars per barrel. According to Fueki et. al (2016), in this period there was a substantial positive contribution of expected future oil supply shocks, which represented the prevailing concern over the oil supply capacity in OPEC countries due to the earlier stagnation in upstream investments and the political uncertainty in Middle East countries. Additionally, realized aggregate demand shocks pushed oil prices up, indicating demand pull stemming from the unexpected rapid growth of emerging economies, especially China and India. Before the global financial crisis, it was widely pointed out that many pension funds and hedge funds had increased their investments in the commodity markets including the crude oil market. The latter is consistent with the large positive increase of oil prices in the first half of 2008.

In the second half of 2008, the WTI fell dramatically from 140 U.S. dollars per barrel to below 40 U.S. dollars per barrel. Figure 6 shows exactly that decline. Fueki et. al (2016) demonstrates through historical decomposition that aggregate demand shocks mainly drove this decline, reflecting the economic recession just after the global financial crisis.

From 2010 to early 2012, the WTI steadily increased from around 80 U.S. dollars per barrel to over 100 U.S. dollars per barrel. The main contributors were realized aggregate demand shocks and expected future oil supply shocks. The former represented the steady growth of emerging economies and the United States after the global financial crisis. The latter was due to the uncertainty on oil supply caused by social and political instability in the Middle East and North Africa before and after the “Arab Spring” (Laura El –Katiri et. al (2014); Fueki et. al (2016)).

From the second half of 2013 to the first half of 2014, expected future oil supply shocks positively contributed to an oil price hike, representing the increasing uncertainty over the Middle East (Syria, Iran and Iraq) and Ukraine-Russia affairs. The sharp fall in oil prices since June 2014 has been driven by a number of factors. According to Baffes et. al (2015), several years of upward surprises in the production of unconventional oil, weakening global demand, a significant shift in OPEC policy, unwinding of some geopolitical risks and an appreciation of the U.S. dollar all led to this plunge.

5.2 Sectoral Local Projections

The previous model gives the general impact of an oil price increase on aggregate series in the economy but masks the heterogenous impacts on economic sectors. In the following Figures, we show the impulse-responses using local projections method for agriculture, industry and mining sectors to estimate the impact of said oil price shock on the above mentioned sectors.

Figures 7, 8 and 9 show the response of FDI , GDP , INF , R , $EMBI$, R and XR to the identified Oil Price shock for Agriculture, Industry and Mining sectors respectively.

At the sectoral level, FDI , GDP and PPI are not significantly impacted for Agriculture. Industry sees its GDP falling between the second and fifth quarters after the shock; neither its PPI nor FDI significantly reacts to the oil price shock.

In Mining, we do see increases in FDI and PPI. The former result confirms that foreign investors in oil and mining sectors positively react to an increase in oil prices. According to Toro et. al (2015), periods of high commodity prices are associated with periods of high capital inflows, good macroeconomic performance, appreciation of the exchange rate, and reduction of the cost of external financing (lower spreads), while the opposite occurs in the periods of low prices (Hamann, 2015, Beltrán 2015, Aizenman et al., 2012). Colombia has not been unaware of this dynamic, where its oil sector has been an important recipient of net inflows of capital through FDI.²¹ On the other hand, GDP does not have a significant response until seventh quarter. Consistent in every SVAR we see a contractionary monetary policy response, an appreciation of the exchange rate and a decrease in country’s risk perception after a positive shock to the oil price.

²¹According to Garavito et. al. (2014), between 2004 and 2013, 52% of total FDI inflows to Colombia were headed to the Mining sector.

5.3 Asymmetric effects of Unanticipated Oil Price Shocks

In this subsection we present the impulse-responses for the enhanced SVAR(1) presented in Section 4.3 and the point estimates (with 95% confidence intervals) of coefficient φ_h for $h = 0, 1, 2, \dots, 10$ of equation (11) of the sectoral Local Projection models, which indicate the existence of asymmetric effects of oil prices over the variables analyzed.

5.3.1 Aggregate Asymmetric SVAR

The first model to be estimated is the SVAR(1) with total aggregate variables for the economy. In Figure 10 we show the response of $FDI, GDP, INF, R, EMBI, R$ and XR to an unexpected shock to OP .

According to the results in Appendix 8.3, the coefficient $g_{21,i}$ of equation (9) is negative and significant for FDI and $EMBI$. In particular, a positive shock has a bigger impact in reducing FDI and risk than what a negative shock does in increasing those variables.

5.3.2 Asymmetric Sectoral Local Projections

Figures 11, 12 and 13 show the point estimates and the confidence interval of coefficient φ_h for $h = 0, 1, 2, \dots, 10$ of equation (11) of the sectoral Local Projection models.

In Agriculture, we see a negative asymmetric effect on GDP, in $t + 3$ and $t + 6$ after the shock at time t . This means that in those periods a positive shock to oil prices has a bigger negative effect on GDP than what a negative shock does in increasing it. Neither FDI nor inflation present asymmetries for this sector.

In Industry, asymmetries are observed on FDI in $t + 4$, $t + 6$ and $t + 8$ after the shock at time t . In $t + 4$ and $t + 6$ there is a negative asymmetric effect on FDI and in $t + 8$ there is a positive asymmetric effect. On inflation, we observe a positive asymmetric effect in $t + 7$. A positive asymmetric effect means that a positive shock to oil prices has a bigger positive effect than what a negative shock does in reducing it.

In Mining we observe a persistent positive asymmetric effect of oil prices on GDP (φ_h is significant for $h = 1, 2, 3, 4, 7, 8, 9$). As described before, this means that a positive shock to oil prices has a bigger positive effect on GDP than what a negative shock does in reducing it. The same is observed in t and $t + 1$ for inflation in this sector.

6 Conclusions

From the second half of 2014, Colombian economy began to be affected by a significant reduction of its terms of trade as a result of the sharp drop in oil prices. This was characterized by being surprising,

accelerated and of considerable magnitude. Not only were external and real sectors impacted, but it reduced confidence, increased risk perception and strongly depreciated the local currency.

Colombia has responded in line with a solid institutional framework of macroeconomic policy that has allowed it to successfully face this type of clashes. The target inflation regime with exchange rate flexibility, the fiscal rule, the preservation of adequate levels of external liquidity, as well as a macro-prudential regulation that advocates financial stability, are some of the characteristics of this framework. In particular, one of the advantages of the flexible exchange rate that operates in Colombia is that depreciation helps to correct external imbalances and stimulate economic activity, softening the negative effects of the fall in oil prices.

In this document we developed a SVAR using the vector data of aggregate variables from 2000:Q1 to 2017:Q3 for the Colombian economy $\{OP, FDI, GDP, INF, R, EMBI, XR\}$. This, in order to identify oil price shocks that impacted Colombia during the period analyzed. With these shocks identified, we used Jordà's (2005) local projections method to estimate the impulse-responses of agricultural, industry and mining sectors.

In general, results from this work show that a positive shock on the oil price over the whole economy does increase GDP and policy rate. As expected, we see a drop in Colombia's risk perception through the EMBI+ and an appreciation of the exchange rate. Central Bank's effort in keeping inflation stable shows up here as there is no significant effect on this variable. Also, due to mix effects on the various sectors in the economy, FDI does not show a significant impact either.

At the sectoral level, Agriculture is not affected either in FDI , GDP and PPI . Industry sees its GDP falling between the second and fifth quarters after the shock. Neither PPI and FDI significantly reacts to the oil price shock. In Mining, we do see FDI and PPI to increase. GDP does not have a significant response. In every model we see a significant contractionary monetary policy behavior, an appreciation of the exchange rate and a decrease in country's risk perception after a positive shock to the oil price. Thus proving the findings in Toro et.al (2015).

There is evidence of negative asymmetric effects of oil price shocks on GDP for Agriculture, contrary to Mining in which there is evidence of a more persistent positive asymmetric effect. In Industry, we found significant asymmetries on FDI and inflation.

7 References

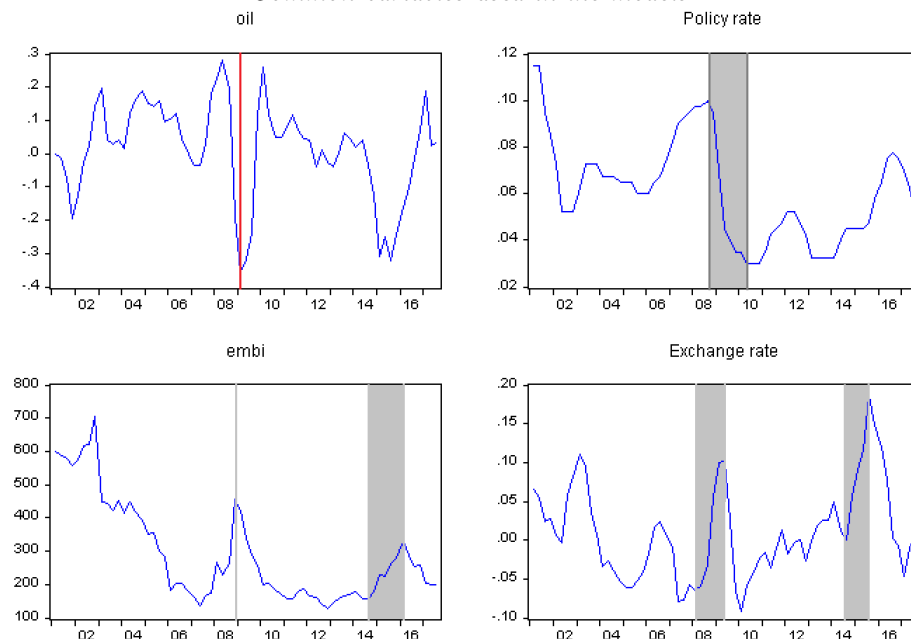
- Ahmed, HJA & Wadud, IKM 2011, ‘Role of oil price shocks on macroeconomic activities: an SVAR approach to the Malaysian economy and monetary responses’, *Energy Policy*, vol. 39, pp. 8062-8069.
- Aizenman, J., Edwards, S., & Crichton, D. (2012). Adjustment patterns to commodity terms of trade shocks: The role of exchange rate and international reserves policies. *Journal of International Money and Finance*, 31(8), 1990–2016.
- Alper, C.E., Torul, O. (2009). Asymmetric Effects of Oil Prices on the Manufacturing Sector in Turkey. 1-22.. Retrieved from http://www.econ.boun.edu.tr/public_html/repec/pdf/200906.pdf
- Bolaji, B.O., Bolaji, G.A. (2010). Investigating the Effects of Increase in Oil Prices on Manufacturing Companies in Nigeria. *The Pacific Journal of Science and Technology* , 11(2), 387-390.
- Ang, JB 2010, ‘Determinants of private investment in Malaysia: what causes the post crisis slumps?’, *Contemporary Economic Policy*, vol. 28, no. 3, pp. 378-391.
- Auerbach, Alan and Yuriy Gorodnichenko, 2013. “Fiscal Multipliers in Recession and Expansion.” In *Fiscal Policy After the Financial Crisis*, edited by Alberto Alesian and Francesco Giavazzi, pp. 63–98. University of Chicago Press.
- Baffes, J., M. A. Kose, F. Ohnsorge, and M. Stocker (2015). The Great Plunge in Oil Prices: Causes, Consequences, and Policy Responses. World Bank Policy Research Note PRS/15/01.
- Beltrán, P. A. (2015). Precio del petróleo y el ajuste de las tasas de interés en las economías emergentes. Borradores de Economía. Banco de la República(901).
- Bernanke, B.S., M. Gertler, and M. Watson (1997), “Systematic Monetary Policy and the Effects of Oil Price Shocks,” *Brookings Papers on Economic Activity*, 1, 91-142.
- Bhar, Ramaprasad., and Malliaris, Anastasios (2011), “Dividends, Momentum, and Macroeconomic Variables as Determinants of the US Equity Premium Across Economic Regimes”, *Review of Behavioral Finance*, 3:27–53.
- Bolaji, Bukola., and Bolaji, Gbolagade (2010), “Investigating the Effects of Increase in Oil Prices on Manufacturing Companies in Nigeria”, *The Pacific Journal of Science and Technology*, Volume 11, Number 2.
- Bouzid, A. (2012). The Relationship of Oil Prices and Economic Growth in Tunisia: A Vector Error Correction Model Analysis . *The Romanian Economic Journal*, XV(43), 3-22.
- Cárdenas-Hurtado, Camilo Alberto, Garavito, Aaron and Toro-Córdoba, Jorge Hernán, (2018), Asymmetric Effects of Terms of Trade Shocks on Tradable and Non-tradable Investment Rates: The Colombian Case, Borradores de Economía, Banco de la Republica de Colombia.
- Cushman, David O., and Tao Zha. 1997. "Identifying Monetary Policy in a Small Open Economy under Flexible Exchange Rates." *Journal of Monetary Economics* 39 (3): 433–48.
- Davis, S.J., and J. Haltiwanger (2001), “Sectoral Job Creation and Destruction Responses to Oil Price Changes,” *Journal of Monetary Economics*, 48, 465-512.
- Dhuyvetter, K., Kastens, T. (2005). Impact of Rising Diesel Prices on Machinery and Whole-Farm Costs. Retrieved from <http://www.agmanager.info/farmmgt/machinery/ImpactDieselPrices090705.pdf>
- Dotsey, M., and M. Reid (1992), “Oil Shocks, Monetary Policy, and Economic Activity.” *Economic Review*, Federal Reserve Bank of Richmond 14–27.

- Elder, J & Serletis, A 2009, ‘Oil price uncertainty in Canada’, *Energy Economics*, vol. 31, pp. 852-856.
- Elder, J & Serletis, A 2010, ‘Oil price uncertainty’, *Journal of Money, Credit and Banking*, vol. 42, pp.1137-1159.
- El –Katiri, L., Fattouh, B., Mallinson, R 2014. “The Arab Uprisings and MENA Political Instability: Implications for Oil & Gas Markets”, *Oxford Institute for Energy Studies*
- Fatima, A & Waheed, A 2011, ‘Effects of macroeconomic uncertainty on investment and economic growth: evidence from Pakistan’, *Transition Studies Review*, vol.18, pp.112-123.
- Ferderer, JP 1996, ‘Oil price volatility and the macroeconomy’, *Journal of Macroeconomics*, vol. 18, pp. 1-26.
- Fueki, T.E. (2016), *Identifying Oil Price Shocks and their Consequences Role of Expectations and Financial Factors in the Crude Oil Market*. Bank of Japan Working Paper Series. p1-25.
- Gonzalez, A., Ocampo, S., Perez, J., and Rodriguez, D (2013), “Output Gap and Neutral Interest Measures for Colombia”, *MONETARIA*, Volume I, Number 2, July - December 2013.
- Hamann, F., Bejarano, J., & Rodríguez, D. (2015). Monetary policy implications for an oil-exporting economy of lower long-run international oil prices. *Borradores de Economía*. Banco de la República(871).
- Herrera, A.M. (2008), “Oil Price Shocks, Inventories, and Macroeconomic Dynamics,” mimeo, Department of Economics, Michigan State University.
- Hooker, M.A. (2002), “Are Oil Shocks Inflationary? Asymmetric and Nonlinear Specifications Versus Changes in Regime,” *Journal of Money, Credit, and Banking*, 34, 540-561.
- Ibrahim, MH, 2011, ‘Level and volatility of stock prices and aggregate investment: The case of Thailand’, *Global Economic Review*, vol. 40, no. 4, pp. 445-461.
- Ibrahim, M, & Ahmed, HJ 2014, ‘Permanent and transitory oil volatility and aggregate investment in Malaysia’, *Energy Policy*, vol.67, pp.552-563.
- Jiménez-Rodríguez, R., and M. Sánchez (2005), “Oil Price Shocks and Real GDP Growth: Empirical Evidence for Some OECD Countries,” *Applied Economics*, 37, 201-228.
- Jones, D.W., P.N. Leiby, and I.K. Paik (2004), “Oil Price Shocks and the Macroeconomy: What Has Been Learned since 1996?” *Energy Journal*, 25, 1-32.
- Jordà, O. 2005. ‘Estimation and Inference of Impulse Responses by Local Projections’, *American Economic Review*, Vol. 95, No. 1, pp. 161-182.
- Kellogg, R 2010, ‘The Effect of Uncertainty on Investment: Evidence from Texas Oil’, *National Bureau of Economic Research Working Paper No. 16541*.
- Kilian, L & Vigfusson, R 2009. “Pitfalls in Estimating Asymmetric Effects of Energy Price Shocks”, *International Finance Discussion Papers*, Number 970.
- Kim, Soyoung. 2001. "International Transmission of U.S. Monetary Policy Shocks: Evidence from VAR's." *Journal of Monetary Economics* 48 (2): 339–72.
- Kuper, GH 2002, ‘Measuring oil price volatility’, *Research Report*, University of Groningen, Research Institute SOM (Systems, Organisations and Management).

- Lee, K., and S. Ni (2002), "On the Dynamic Effects of Oil Price Shocks: A Study Using Industry Level Data," *Journal of Monetary Economics*, 49, 823-852.
- Melo-Becerra, Ligia A., Ramos-Forero, Jorge E., Parrado-Galvis, Ligia M., Zarate-Solano, Hector M. (2016). "Bonanzas y crisis de la actividad petrolera y su efecto sobre la economía colombiana". Borradores de Economía. Banco de la República (961).
- Mork, K.A. (1989), "Oil and the Macroeconomy. When Prices Go Up and Down: An Extension of Hamilton's Results," *Journal of Political Economy*, 97, 740-744.
- Newey, Whitney K and Kenneth D West, 1987. "A Simple, Positive Semi-definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix." *Econometrica* 55(3): 703-08.
- Petersen, D.M., Yucel, M.K., Phillips, K.R. (1994). The Texas Construction Sector: The Tail That Wagged the Dog. Federal Reserve Bank of Dallas, 23-34.
- Pradhan, G, Schuster, Z & Upadhyaya, KP 2004, 'Exchange rate uncertainty and the level of investment in selected South-east Asian countries', *Applied Economics*, vol. 36, pp. 2161-2165.
- Rafiq, R, Salim, R, & Bloch, H 2009, 'Impact of crude oil price volatility on economic activities: An empirical investigation in the Thai economy', *Resource Policy*, vol. 34, pp.121-132.
- Rafiq, S & Salim, RA 2011, 'The linkage between energy consumption and income: A multivariate cointegration analysis in six emerging economies of Asia', *International Journal of Emerging Markets*, vol. 6, no. 1, pp. 50-73
- Valerie A. Ramey and Sarah Zubairy, "Government Spending Multipliers in Good Times and in Bad: Evidence from US Historical Data," *Journal of Political Economy* 126, no. 2 (April 2018): 850-901.
- Rodriguez, R.J., Sanchez, M. (2004). Oil Price Shocks and Real GDP Growth: Empirical Evidence for Some OECD Countries. Germany.
- Servén, L 2003, 'Real exchange rate uncertainty and private investment in LDCs', *Review of Economics and Statistics*, vol. 85, pp. 212-217.
- Syed, N. . (2010). Measuring the Impact of Changing Oil Prices and other Macro Economic Variables on GDP in the Context of Pakistan's Economy . *International Research Journal of Finance and Economics* , 52, 41-49.
- Toro, J, Garavito, A, López, C y Montes, E (2015). El choque petrolero y sus implicaciones sobre la economía colombiana. Borradores de economía, 906.

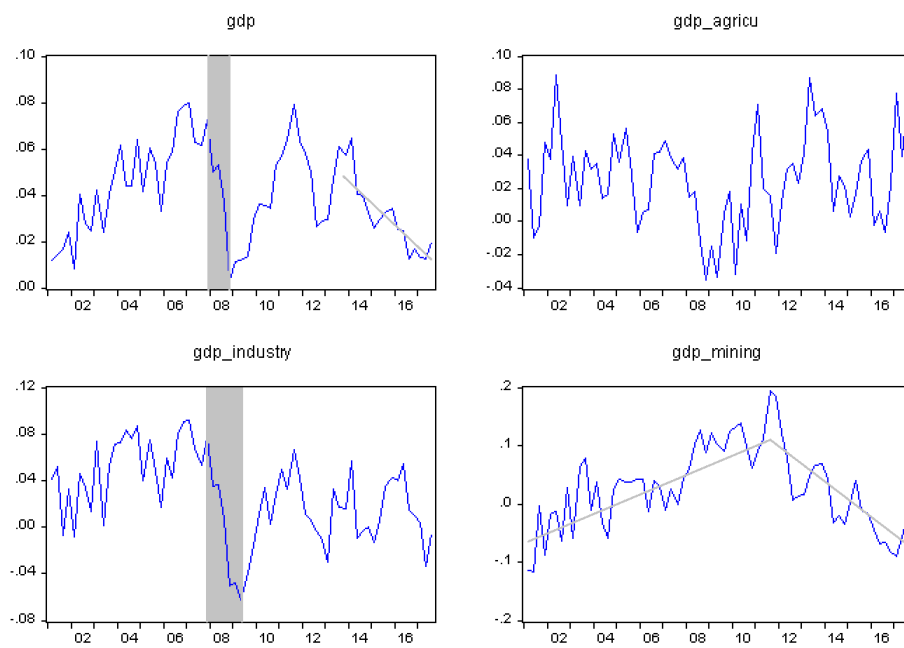
8 Figures

Figure 1
Common variables used in the models



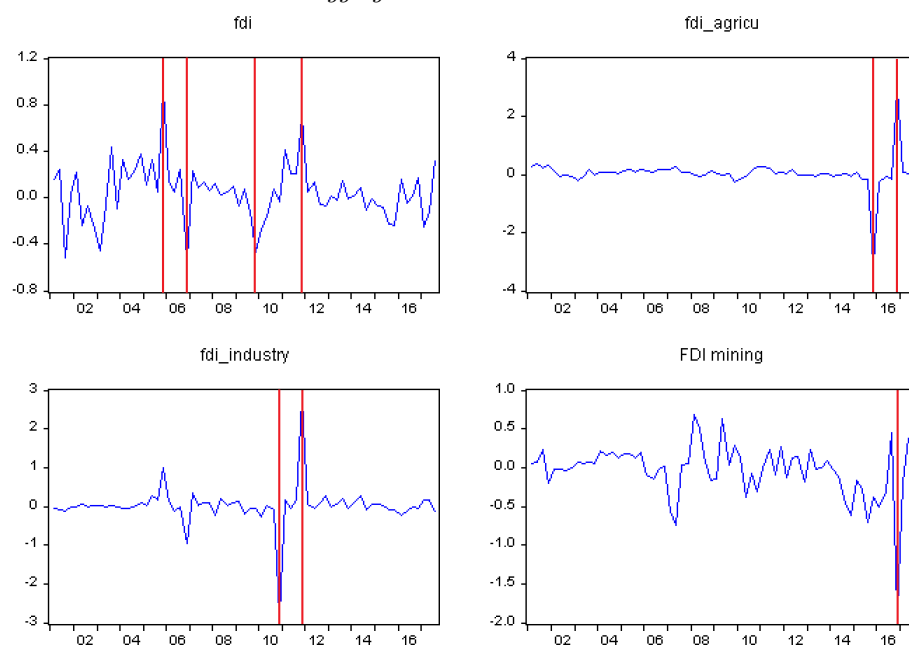
Source: Banco de la República, World Bank and Bloomberg. Data coverage from 2000:Q1 to 2017:Q3.

Figure 2
Aggregate and sectoral GDP



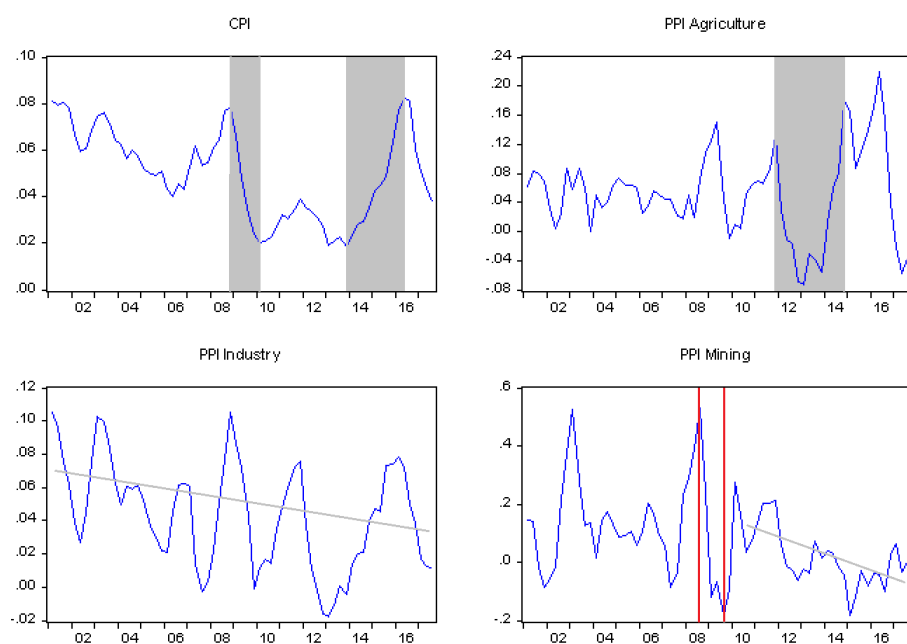
Source: Departamento Administrativo Nacional de Estadística (DANE). Data coverage from 2000:Q1 to 2017:Q3.

Figure 3
Aggregate and sectoral FDI



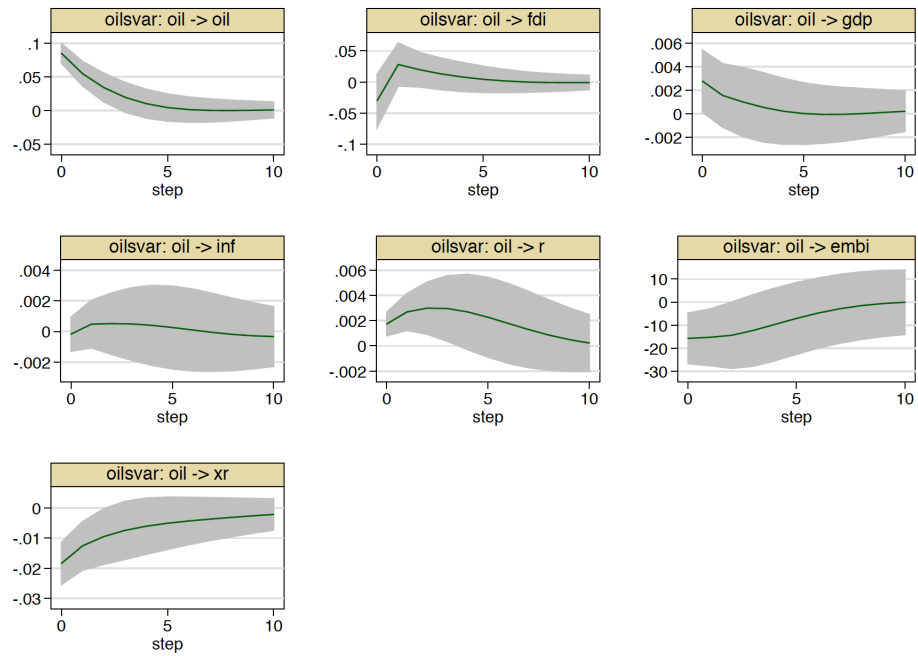
Source: Banco de la República. Data coverage from 2000:Q1 to 2017:Q3.

Figure 4
Aggregate and sectoral Inflations



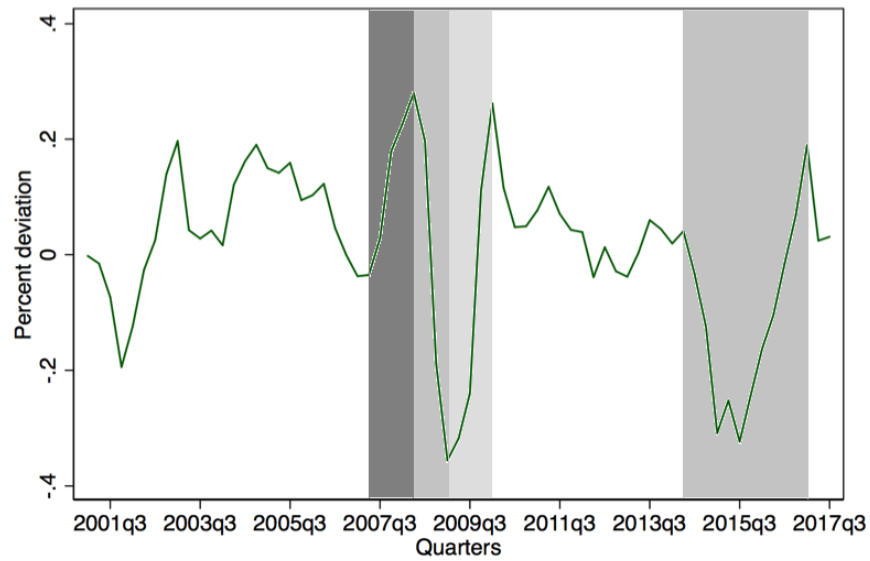
Source: Departamento Administrativo Nacional de Estadística (DANE). Data coverage from 2000:Q1 to 2017:Q3.

Figure 5
Impulse - response to a shock in Oil Price for the entire economy



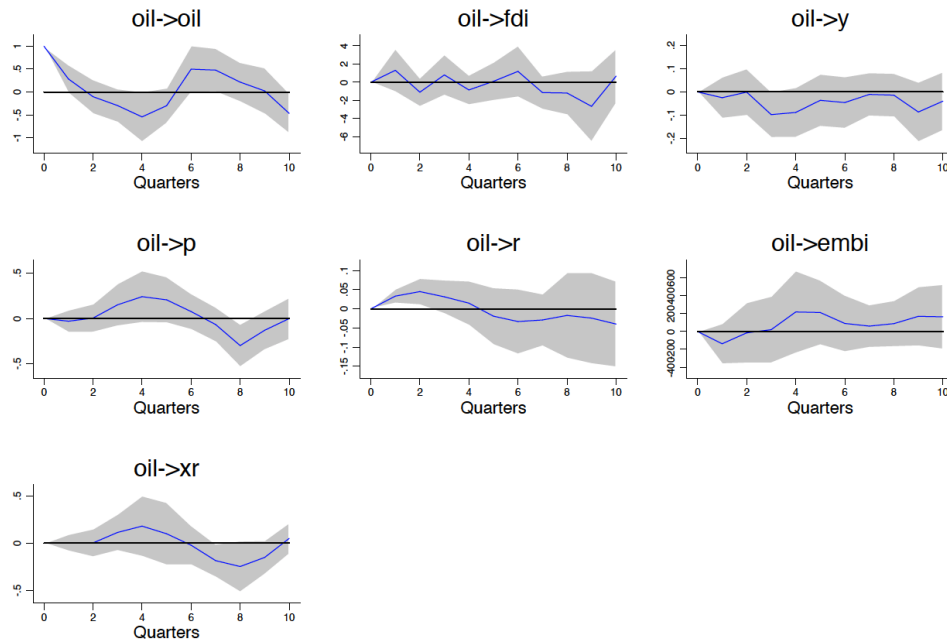
Source: Author's calculations

Figure 6: Oil price shocks



Source: Author's calculations

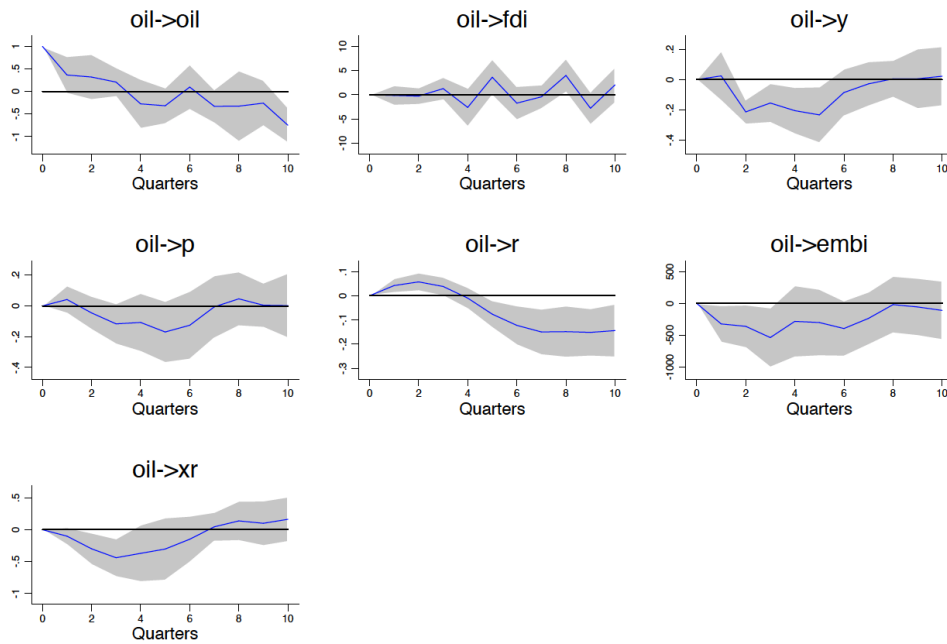
Figure 7
LP Impulse - response to a shock in Oil Price for agriculture



Source: Author's calculations

Note: Newey-West standard error bands are 95% confidence intervals

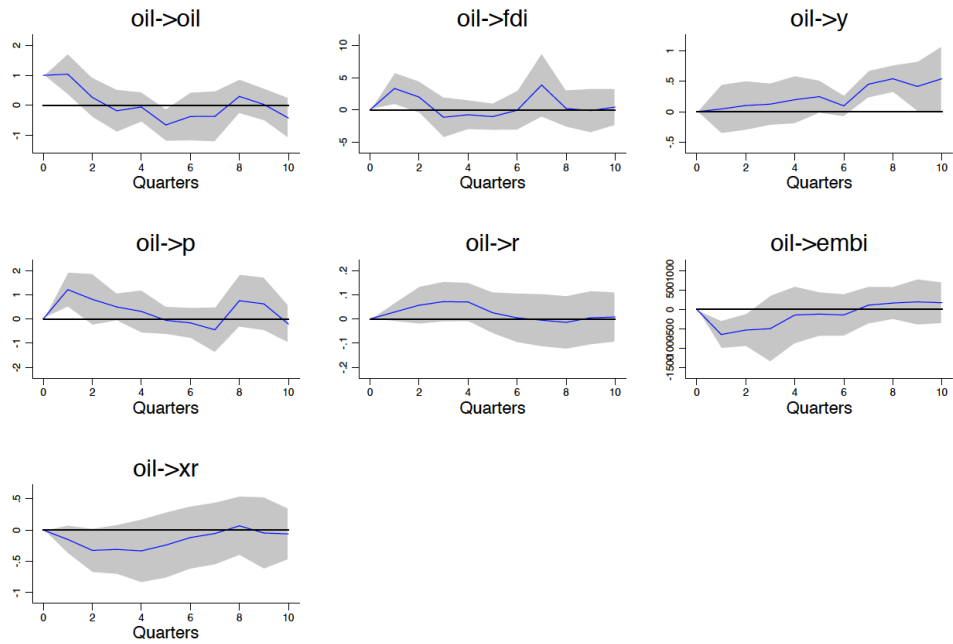
Figure 8
Impulse - response to a shock in Oil Price for industry



Source: Author's calculations

Note: Newey-West standard error bands are 95% confidence intervals

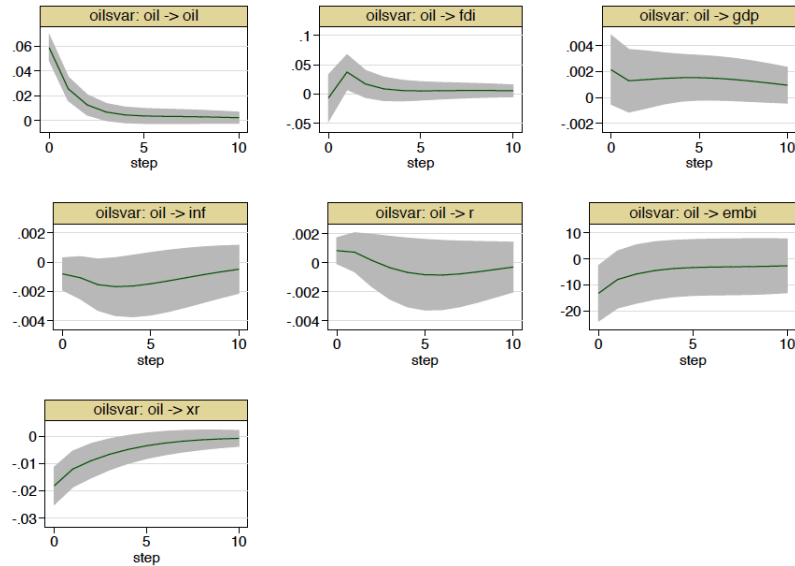
Figure 9
Impulse - response to a shock in Oil Price for mining



Source: Author's calculations

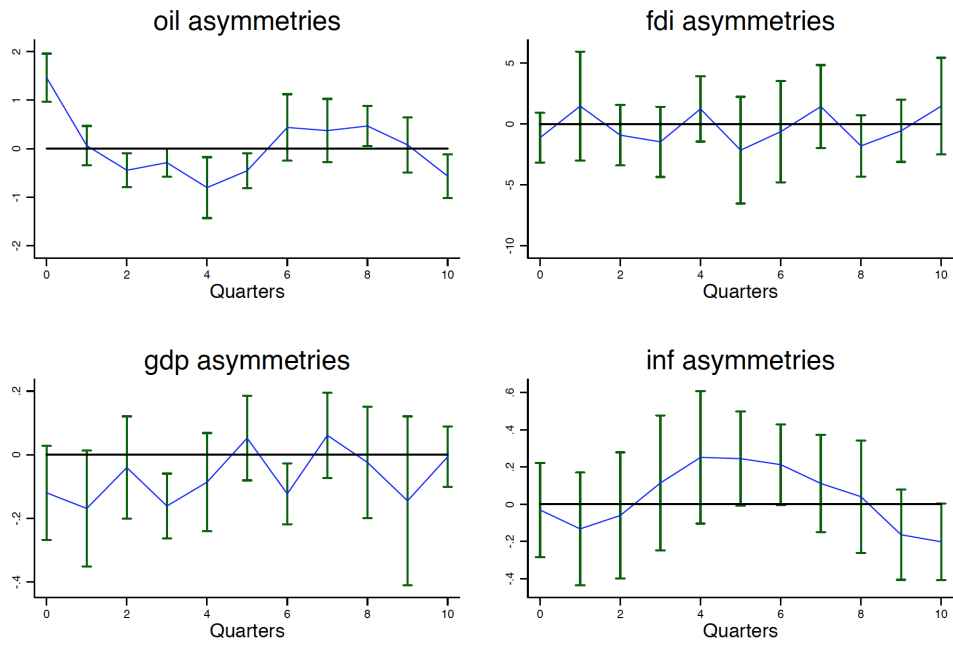
Note: Newey-West standard error bands are 95% confidence intervals

Figure 10
Impulse - response to a shock in Oil Price for the entire economy



Source: Author's calculations

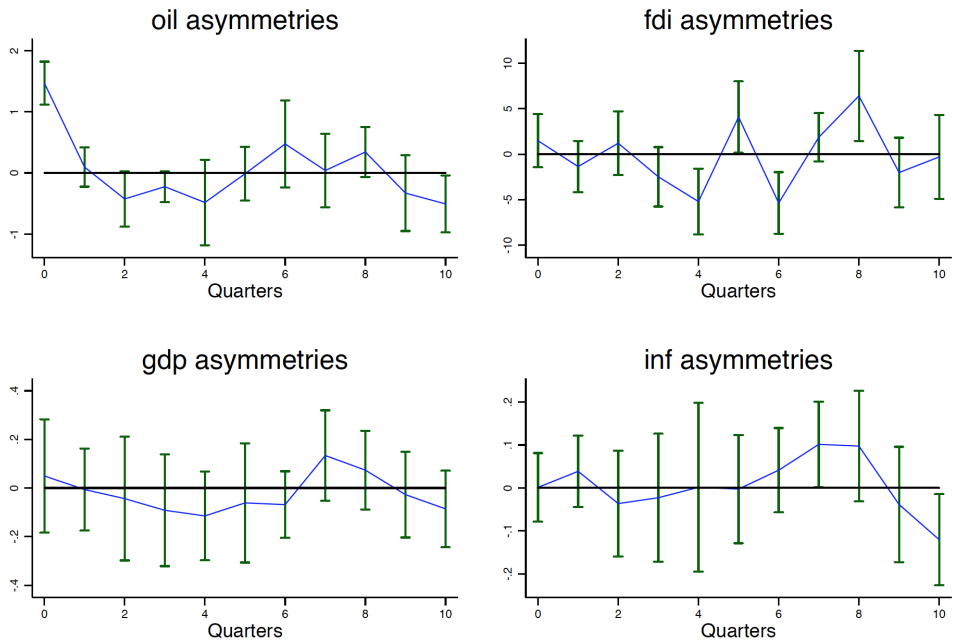
Figure 11
Local Projections point estimates of φ_h for Agriculture



Source: Author's calculations

Note: Error bands are 95% confidence intervals

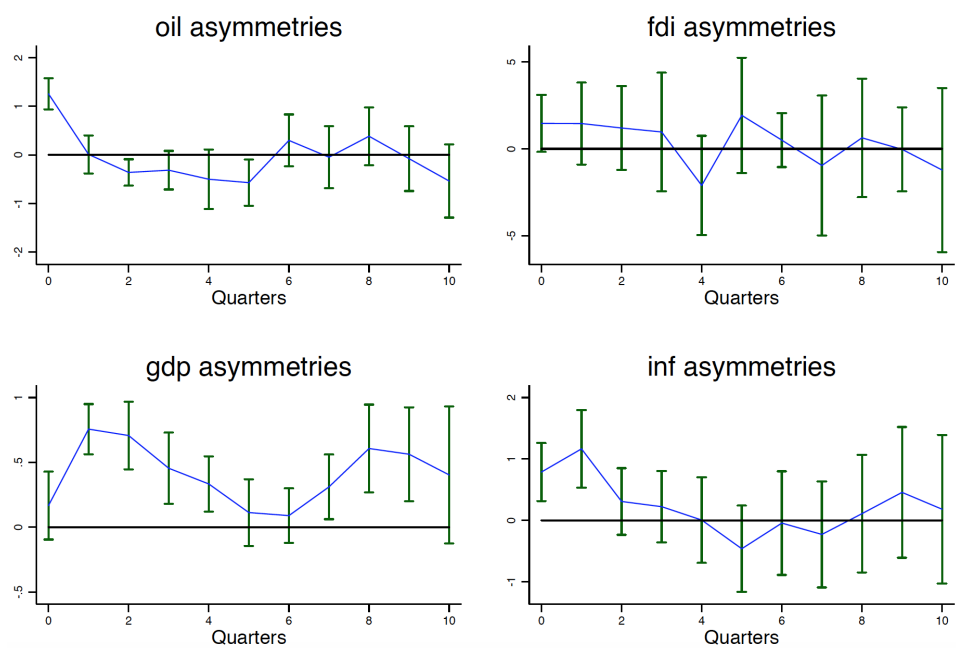
Figure 12
Impulse - response to a shock in Oil Price for Industry



Source: Author's calculations

Note: Error bands are 95% confidence intervals

Figure 13
Impulse - response to a shock in Oil Price for Mining



Source: Author's calculations

Note: Error bands are 95% confidence intervals

9 Appendixes

9.1 Appendix A: VAR Autorregression Estimates for aggregate economy

	OIL	FDI	GDP	IPC	POL_RATE	EMBI	XR
OIL(-1)	0.532794 -0.1251 [4.25892]	0.01104 -0.26139 [0.04223]	-0.002352 -0.01637 [-0.14371]	0.015121 -0.00677 [2.23224]	0.016646 -0.00595 [2.79874]	-63.08086 -68.8959 [-0.91560]	0.044908 -0.04685 [0.95845]
FDI(-1)	0.035772 -0.04996 [0.71603]	0.015757 -0.10439 [0.15095]	0.009059 -0.00654 [1.38610]	-0.007102 -0.00271 [-2.62531]	-0.002994 -0.00238 [-1.26076]	-24.70441 -27.5136 [-0.89790]	-0.014015 -0.01871 [-0.74900]
GDP(-1)	0.812707 -0.76008 [1.06923]	4.991153 -1.58815 [3.14275]	0.693792 -0.09943 [6.97737]	0.181026 -0.04116 [4.39851]	0.216407 -0.03614 [5.98870]	274.3448 -418.596 [0.65539]	-0.19212 -0.28468 [-0.67486]
IPC(-1)	1.1302 -1.69486 [0.66684]	7.454082 -3.5413 [2.10490]	-0.314408 -0.22172 [-1.41802]	0.755479 -0.09177 [8.23218]	0.241641 -0.08058 [2.99889]	240.7264 -933.398 [0.25790]	-0.420289 -0.63479 [-0.66209]
POL_RATE(-1)	-1.80543 -1.18598 [-1.52231]	-3.182124 -2.47803 [-1.28413]	0.018732 -0.15515 [0.12073]	0.146647 -0.06422 [2.28361]	0.801163 -0.05638 [14.2091]	609.8775 -653.146 [0.93375]	0.107399 -0.44419 [0.24178]
EMBI(-1)	0.000179 -0.00012 [1.49169]	-0.000404 -0.00025 [-1.61051]	2.42E-05 -1.60E-05 [1.53999]	6.80E-06 -6.50E-06 [1.04534]	-1.69E-05 -5.70E-06 [-2.95308]	0.870522 -0.06617 [13.1562]	1.32E-05 -4.50E-05 [0.29252]
XR(-1)	-0.777199 -0.33294 [-2.33434]	-0.779195 -0.69566 [-1.12008]	-0.021285 -0.04356 [-0.48869]	0.083424 -0.01803 [4.62755]	0.055623 -0.01583 [3.51407]	-68.25198 -183.358 [-0.37223]	0.886632 -0.1247 [7.11020]
C	-0.016635 -0.05423 [-0.30672]	-0.213733 -0.11332 [-1.88613]	0.01988 -0.00709 [2.80202]	-0.00712 -0.00294 [-2.42446]	-0.004875 -0.00258 [-1.89058]	-24.22403 -29.8679 [-0.81104]	0.018076 -0.02031 [0.88988]
D_IED_NEG	-0.027517 -0.09789 [-0.28110]	-0.723225 -0.20454 [-3.53594]	0.01234 -0.01281 [0.96362]	-0.009887 -0.0053 [-1.86539]	0.000396 -0.00465 [0.08506]	-36.04269 -53.9104 [-0.66857]	-0.00936 -0.03666 [-0.25530]
D_IED_POS	-0.060679 -0.09534 [-0.63643]	0.77443 -0.19921 [3.88745]	-0.017939 -0.01247 [-1.43826]	0.00223 -0.00516 [0.43196]	-0.00131 -0.00453 [-0.28896]	-10.66842 -52.5075 [-0.20318]	0.001489 -0.03571 [0.04171]
D_IPC_NEG	-0.063571 -0.09951 [-0.63881]	0.21766 -0.20793 [1.04681]	-0.004602 -0.01302 [-0.35349]	-0.013768 -0.00539 [-2.55514]	-0.017369 -0.00473 [-3.67128]	-82.80865 -54.8047 [-1.51098]	0.025541 -0.03727 [0.68526]
R-squared	0.654267	0.491418	0.681265	0.939861	0.96201	0.896147	0.709649

Adj. R-squared	0.591406	0.398949	0.623314	0.928927	0.955102	0.877265	0.656857
Sum sq. resids	0.475509	2.075955	0.008138	0.001394	0.001075	144219.9	0.066703
S.E. equation	0.092982	0.19428	0.012164	0.005035	0.004421	51.20723	0.034825
F-statistic	10.40823	5.314389	11.75574	85.95488	139.2739	47.45961	13.44256
Log likelihood	69.13985	20.50476	203.3791	261.5994	270.1852	-347.4015	133.9562
Akaike AIC	-1.761814	-0.288023	-5.829671	-7.593921	-7.854098	10.86065	-3.725945
Schwarz SC	-1.396871	0.076919	-5.464729	-7.228979	-7.489155	11.22559	-3.361003
Mean dependent	0.012776	0.042502	0.040436	0.049105	0.060379	287.124	0.00822
S.D. dependent	0.145463	0.250595	0.019819	0.018885	0.020862	146.1662	0.05945

9.2 Appendix B

VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	346.6517	NA	9.55E-14	-10.11593	-9.163421	-9.741301
1	646.6866	495.2957	3.38E-17	-18.08529	-15.46590*	-17.05507
2	725.8329	113.0662	1.42E-17	-19.04231	-14.75605	-17.35650*
3	788.7546	75.90548	1.12E-17	-19.48427	-13.53112	-17.14287
4	863.6463	73.70298*	7.41e-18*	-20.30623*	-12.6862	-17.30923

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

9.3 Appendix C: VAR Autorregression Estimates for aggregate economy with asymmetries in Oil Prices

Sample (adjusted): 2001Q2 2017Q2

Included observations: 65 after adjustments

Standard errors in () & t-statistics in []

	OIL	FDI	GDP	IPC	POL RATE	EMBI	XR
OIL(-1)	0.439211 -0.10629 [4.13225]	0.266716 -0.29259 [0.91156]	0.0002 -0.02003 [0.01000]	0.008838 -0.00824 [1.07309]	0.014746 -0.00673 [2.19055]	37.99309 -80.9733 [0.46921]	0.030756 -0.05577 [0.55152]
FDI(-1)	0.036046 -0.03526 [1.02239]	0.036955 -0.09706 [0.38076]	0.009277 -0.00664 [1.39632]	-0.007405 -0.00273 [-2.71055]	-0.00306 -0.00223 [-1.37038]	-20.5304 -26.8595 [-0.76436]	-0.015056 -0.0185 [-0.81391]
GDP(-1)	0.499948 -0.56496 [0.88492]	5.851155 -1.55524 [3.76222]	0.671691 -0.10646 [6.30943]	0.184472 -0.04378 [4.21375]	0.198903 -0.03578 [5.55904]	172.3078 -430.402 [0.40034]	-0.078651 -0.29642 [-0.26534]
IPC(-1)	-0.168677	7.588083	-0.380709	0.771678	0.202099	-10.63371	-0.098172

	-1.24284 [-0.13572]	-3.42131 [2.21789]	-0.23419 [-1.62562]	-0.09631 [8.01274]	-0.07871 [2.56760]	-946.823 [-0.01123]	-0.65208 [-0.15055]
POL_RATE(-1)	-0.806644 -0.86499 [-0.93255]	-3.594188 -2.38117 [-1.50942]	0.065163 -0.16299 [0.39979]	0.139829 -0.06703 [2.08615]	0.832066 -0.05478 [15.1888]	720.3366 -658.971 [1.09312]	-0.117793 -0.45383 [-0.25955]
EMBI(-1)	8.31E-05 -8.60E-05 [0.96449]	-0.000268 -0.00024 [-1.13252]	2.10E-05 -1.60E-05 [1.29700]	5.79E-06 -6.70E-06 [0.86705]	-2.00E-05 -5.50E-06 [-3.67363]	0.884163 -0.06561 [13.4768]	2.84E-05 -4.50E-05 [0.62831]
XR(-1)	-0.031744 -0.27493 [-0.11546]	-0.841692 -0.75683 [-1.11213]	0.009955 -0.05181 [0.19216]	0.079478 -0.0213 [3.73066]	0.075745 -0.01741 [4.35025]	-21.05615 -209.446 [-0.10053]	0.737571 -0.14425 [5.11329]
C	-0.053737 -0.03981 [-1.34970]	-0.233933 -0.1096 [-2.13443]	0.01955 -0.0075 [2.60590]	-0.007751 -0.00309 [-2.51244]	-0.00527 -0.00252 [-2.08987]	-10.28626 -30.331 [-0.33913]	0.018963 -0.02089 [0.90778]
OIL_POS	0.763366 -0.17804 [4.28755]	-1.116204 -0.49012 [-2.27741]	0.009402 -0.03355 [0.28024]	0.020822 -0.0138 [1.50921]	0.019725 -0.01128 [1.74930]	-335.5719 -135.637 [-2.47404]	-0.038815 -0.09341 [-0.41551]
OIL_POS1	0.407506 -0.16856 [2.41752]	0.382707 -0.46403 [0.82475]	0.026037 -0.03176 [0.81971]	-0.012016 -0.01306 [-0.91990]	0.011352 -0.01068 [1.06340]	178.0345 -128.416 [1.38639]	-0.126632 -0.08844 [-1.43184]
D_IED_NEG	0.03159 -0.06935 [0.45550]	-0.790138 -0.19091 [-4.13875]	0.01398 -0.01307 [1.06979]	-0.00913 -0.00537 [-1.69901]	0.002118 -0.00439 [0.48233]	-47.81911 -52.8337 [-0.90509]	-0.017065 -0.03639 [-0.46898]
D_IED_POS	-0.034165 -0.06715 [-0.50878]	0.746751 -0.18485 [4.03970]	-0.01735 -0.01265 [-1.37118]	0.002672 -0.0052 [0.51345]	-0.000607 -0.00425 [-0.14263]	-17.92756 -51.1568 [-0.35044]	-0.001186 -0.03523 [-0.03367]
D_IPC_NEG	-0.074744 -0.07126 [-1.04883]	0.289411 -0.19618 [1.47525]	-0.00378 -0.01343 [-0.28152]	-0.015198 -0.00552 [-2.75215]	-0.017695 -0.00451 [-3.92066]	-60.99242 -54.2909 [-1.12344]	0.021324 -0.03739 [0.57032]
R-squared	0.838421	0.578816	0.685565	0.942109	0.968431	0.906613	0.733762
Adj. R-squared	0.801134	0.48162	0.613003	0.92875	0.961145	0.885062	0.672322
Sum sq. resids	0.222175	1.683643	0.007889	0.001334	0.000891	128944.6	0.06116
S.E. equation	0.065365	0.179938	0.012317	0.005065	0.00414	49.79662	0.034295
F-statistic	22.48536	5.95513	9.447996	70.52015	132.93	42.0685	11.94282
Log likelihood	92.32606	26.50539	200.8114	258.5712	271.6848	-338.9954	134.2502
Akaike AIC	-2.440802	-0.415551	-5.778813	-7.556037	-7.959533	10.83063	-3.730776
Schwarz SC	-2.005924	0.019327	-5.343936	-7.12116	-7.524655	11.26551	-3.295899
Mean dependent	0.012494	0.038066	0.040757	0.049284	0.0605	288.4847	0.008279
S.D. dependent	0.146577	0.249919	0.019799	0.018975	0.021001	146.8818	0.059911

