The influence of oil price shocks on the Chilean, Colombian, and Brazilian macroeconomies

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Abstract

This paper uses structural VAR models to analyze the influence of an unexpected increase in oil prices on the Chilean, Colombian, and Brazilian macroeconomies, with a focus on real gross domestic product and inflation rates. A pre-determined, positive shock to oil prices is followed by real economic contractions in the Chilean and Colombian economies. On the other hand, the Brazilian real economy remains unaffected over its full-sample and in its recent years as a net oil exporter, although it experiences recessionary effects during its years as a net oil importer. Chilean and Colombian core inflation and Brazilian headline inflation all increase. All responses occur in the short run only and are robust to changes in specification.

Keywords: oil prices, structural VAR, real economy, inflation rate, pass-through effect.

1. Introduction

The relationship between oil prices and the macroeconomy has been studied for decades, with Hamilton's (1984) seminal paper being an important starting point for this area of research.[1] The last century's researchers focused on the American economy, other Western, developed economies, and the Japanese economy, as noted by many applied researchers (e.g. Cunado & Perez de Gracia, 2005; Ran & Voon, 2012; Pedersen & Ricaurte, 2014; Quintero Otero, 2020). In general, the literature on this topic, both old and recent, suggests that oil prices are often related to real economic activity and inflation rates. The direction of these relationships is often a point of contention among researchers, with some finding contradictory evidence. Nonetheless, if the price of oil has the potential to influence business cycles, whether positively or negatively, then oil prices in relation to the macroeconomy should be studied to gain insights into the individual experience of the world's economies, thus giving policymakers additional insight for more effective decision-making.

Since the literature has revisited developed economies for over four decades, in the present reality of easily, freely accessible macroeconomic data for many emerging economies, then researchers should take it upon themselves as an academic duty, as several have already been doing successfully, to study economies which previously received little or no attention. This paper contributes to the applied literature which in the last two decades has explored the oil price-macroeconomy relationship in emerging economies. Specifically, the Chilean, Colombian, and Brazilian economies are investigated since they are South American economies which have only received modest attention with regards to the oil price-macroeconomy relationship. Furthermore,

[1] See Mork (1994), Brown and Yucel (2002), Cunado & Perez de Gracia (2003), Kilian (2008), Hamilton (2008), Blanchard & Galli (2007) for good reviews of the influence of oil prices on the macroeconomies of developed economies.

they are the only South American economies which have the necessary accessible data for analyzing this relationship. One major contribution is the use of econometric methods to revisit the oil price-macroeconomy relationship in the Chilean, Colombian, and Brazilian economies. One minor contribution is a precise look into the Brazilian economy's responses before and after it becomes a net exporter of oil, a detail overlooked by all researchers which have studied the oil price-macroeconomy relationship in the applied literature (e.g. Cavalcanti and Jalles, 2013; Souza and Mattos, 2021). A second minor contribution is the exploration of the applied literature on the oil price-macroeconomy relationship in areas which are less often studied, namely Asian, South American, and African economies.

The economies under study in this paper are among the largest in South America, but they differ in their relationship with regards to oil trade. Throughout their sample-periods, the Chilean and Colombian economies remain a net oil importer and exporter, respectively. The Brazilian economy becomes a net exporter in 2006, which allows for an accidently more diverse analysis since it reacts differently to an unexpected oil price increase before and after this change.

The influence of an unexpected increase in oil prices on these economies is analyzed using a simple structural VAR with a Cholesky ordering of endogenous variables. The conceptual framework which motivates this analysis has two channels of influence through which an increase in oil prices can negatively influence the real economy. The first is the demand-side channel, characterised by income being transferred from oil importing to oil exporting economies, resulting in decreased aggregate demand in oil importing economies and increased aggregate demand in oil exporting economies. The second is the supply-side channel, where increased oil prices lead to higher input costs for firms, who then purchase less energy (oil). This reduces capital and labour

productivity, resulting in lower production for individual firms and decreased aggregate supply (Cunado and Perez de Gracia, 2005; Jimenez-Rodriguez & Sanchez, 2005).

The remainder of this paper is structured as follows: Section 2 reviews both the oil price-macroeconomy and inflation pass-through effect literatures. Section 3 gives context regarding the economic reality of the economies under study and how this relates to the assumptions held for the analyses. Section 4 is a discussion on econometric models and data. Sections 5 and 6 contain discussions of the main results and their alternative specifications used to further assess robustness. Finally, section 7 concludes this paper by summarizing the main insights discovered.

2. Literature review

Researchers of the last century generally agreed that there existed a negative relationship between oil prices and the real economy, with Mork et al. (1994) claiming to that this relationship had been "accepted as an empirical fact". Previous research focused on the economies of the United States, Western Europe, and Japan. Does their claim hold up in more recent decades? Does it hold for economies across the globe? To address these questions, recent applied literature which examines oil price-macroeconomy relationships, with a focus on the real economy and inflation, across different areas of the world is explored.[2]

According to some researchers (Edelstein & Kilian, 2007; Blanchard & Galli, 2007; Herrara & Pesavento, 2009; Kilian, 2009; Baumeister & Peersman, 2013), there is evidence that in the American setting, the negative relationship between oil prices and the real economy has been declining in magnitude since the mid-eighties, around the onset of the Great Moderation.

[2] As of the writing of this paper, there does not appear to yet exist a review of the literature for all areas of the world for which applied research on this topic has been conducted.

Despite this decline, there remains evidence that the relationship holds across many developed economies including that of the United States, well into recent years. For instance, Cunado & Perez de Gracia (2003) and Jimenez-Rodriguez & Sanchez (2005) find that between the 1960s and the early 2000s, the negative relationship holds across most North American and Western European economies. The former study finds that even when a structural break in the mid-eighties is taken into consideration, the relationship still tends to hold. The latter find an interesting result, which is that the real economies of Norway and the United Kingdom react in opposite directions, despite both being net oil exporters. The former's real economy expands whereas the latter contracts. Furthermore, Raduzzi & Ribba (2020) find that the negative relationship holds across small and *medium* (economies like that of Italy, as referred to by these researchers) Eurozone economies for the period 1999 to 2015. In the case of the American economy, Oladosu et al.'s (2018) meta-analysis suggests that most of the recent literature still finds that the negative relationship holds. Overall, many developed, Western real economies seem to have been and still are negatively influenced by unanticipated increases to the price of oil.

On the other hand, evidence for Asian economies is varied. From the 1970s to the early 2000s, Abeysinghe (2001) and Cunado & Perez de Gracia (2005) find a negative relationship for many Asian economies, whereas Ran and Voon (2012) find no relationship among the economies they study during the same period. Using a longer sample which reaches up to the year 2014, Khan et al. (2019) also find no relationship for many Asian economies. Research conducted for Asian economies consists of a blend of net oil importers and exporters, and the evidence suggests that this is not a significant factor in determining the relationship. Overall, the evidence for Asian economies suggests that the negative relationship between oil prices and the real economy does not tend to hold consistently.

In the African setting, one where net oil exporters are rampant, the relationship appears ambiguous. Imayemi & Fowowe (2011) find a negative relationship in a small group of net oil exporting African economies for the period 1970 to 2006, whereas Omolade et al. (2019) find a positive relationship among a larger group of net oil exporters for the period 1980 to 2016. Other studies find that the negative relationship between oil prices and the real economy of Ghana holds during the period 2000 to 2016 (Dramani and Frimpong, 2020) and that a positive relationship occurs in the Nigerian economy for the period 1970 to 2008 (Chuku, 2012).

In South America, for the period 1999 to 2020, Souza and Mattos (2021) investigate structural shocks and find that positive oil shocks stemming from a rise in global demand is followed by increased real growth in the Chilean, Colombian, and Brazilian real economies, whereas other shocks (oil supply and oil-specific demand shocks) do not have any influence. Using a similar framework in the Colombian setting only, Quintero Otero (2020) finds that both global demand and oil-specific demand shocks positively influence this economy's real economy during the period 1994 to 2017. Cavalcanti and Jalles (2013) study unanticipated oil price shocks imposed on the Brazilian economy during the sample periods 1975 to 1984 and 1985 to 2008. They find that in neither case does a positive oil shocks have an influence on the real economy nor headline inflation. Pinchera and Garcia (2007) find the same result for the Chilean real economy, which remains unaffected for the period 1999 to 2005 (using monthly data). Again, conducting an analysis of structural shocks during the period 1995 to 2011, Pedersen and Ricaurte (2014) find that positive shocks to either oil supply or oil-specific demand are associated with real economic contraction in the Chilean economy, whereas global demand shocks are associated with real economic expansion. Overall, the evidence of an unanticipated positive shock to oil prices is

associated with no effect on the Chilean and Brazilian real economies. In the case of analyses which are broken-down into different structural shocks, there are existing relationships.

Another relevant area of research undertaken by applied researchers is the pass-through of oil price shocks to consumer prices. A great deal of applied research on this topic concerns the American economy, for which some researchers find that the pass-through effect has been dwindling since around the early to mid-eighties for both headline inflation (Ramey & Vine, 2011; Sekine, 2020) and core inflation (Hooker, 2002; Clark & Terry, 2010). In Europe, during the period 1960 to 1999, Cunado & Perez de Gracia (2003) find some pass-through to headline inflation. In the following period of 2000 to 2015, Raduzzi and Ribba (2020) also find pass-through into headline inflation, whereas Castro & Jimenez-Rodriguez (2017) find none. A study conducted by Pinchera & Garcia (2007) involves the analysis of many developed economies, alongside that of Chile, during the period 1999 to 2005 (using monthly data). They find that all economies under study experience a pass-through into headline inflation. In the case of core inflation, all economies, except for two, experience a pass-through. Evidence of headline inflation pass-through in the Chilean economy is also found by Pedersen & Ricaurte (2014) for the period 1995 to 2011. In the Brazilian case, Cavalcanti & Jalles (2013) find no pass-though to headline inflation. Elsewhere, Ran and Voon (2012) and Cunado and Perez de Gracia (2005) find some pass-through of oil price shocks into headline inflation in several Asian economies. Pass-through into headline inflation is also found among net oil exporting African economies (Imayemi & Fowowe, 2011; Omolade et al., 2019).

Overall, the negative relationship between oil prices and the real economy studied via an unanticipated increase in the price of oil tends to consistently hold, even to this day, only in developed economies. Hence, Mork's claim holds true for these economies, but it does not appear

to hold elsewhere. Regarding net oil exporters, the negative relationship between oil prices and the real economy is not consistently reversed or nullified across individual geographical areas nor across the world. Years after Cunado and Perez de Gracia's (2005) suggestion that more research should be conducted on this peculiarity, the accumulated evidence suggest that net oil exporters are not consistently better off than their net importing counterparts following a large increase in the price of oil. As for the pass-through into consumer prices, often proxied via headline inflation, it occurs in many cases across different areas of the world, whether an economy is a net importer or exporter of oil.

3. Economic context

In this paper, shocks imposed to the price of oil are considered pre-determined. To characterise the shocks as such, two assumptions are held. (1) The economies under study have little influence on global demand and supply conditions. This implies that changes in their economic activities, and consequently their demand for oil, should not be substantial enough as to affect its price. (2) They are not large oil exporters. This implies that changes in their supply of oil to the global economy should not be substantial enough as to affect its price. If (1) and (2) hold, their individual contributions to the world economy should be negligeable enough to not be the source of a shock that could influence the price of oil.

To get insight into the reality of the economies under study during the period 1995-2019, some stylized facts are presented.[3] These can help identify how their economic realities relate to

[3] The statistics from sections 3.1 and 3.2 are derived from World Bank Development Indicators, and those for section 3.3 are from the U.S. Energy Information Administration. The former's data are annual series ranging from 1995-2019 of real gross domestic product, and real exports and imports of goods and services in US dollars, adjusted for headline inflation. The latter's data are annual series ranging from 1995-2016 of crude oil exports and imports in millions of barrels per day.

the assumptions. To understand how much weight the Brazilian, Colombian, and Chilean economies have in the global economy, their shares of the real global economy are compared to those of other economies in section 3.1. To understand their openness to trade and how much their trade weighs in the global exchanges of goods and services, some trade figures are presented in section 3.2. In section 3.3, the weight of their oil exports and imports are compared to those of other economies.

3.1 Real economic size

Table 1. Real economic size and trade statistics for the economies under study

Economy	Share of world GDP	Trade openness index	Exports (share of own GDP)	Imports (share of own GDP)	Exports (share of world exports)	Imports (share of world imports)
Chile	0.32	63.03	36.87	26.16	0.43	0.32
Colombia	0.43	33.30	16.16	17.14	0.25	0.28
Brazil	3.12	19.92	10.32	9.61	1.17	1.15

The Brazilian economy is the largest under study, with its Colombian and Chilean neighbours trailing far behind. As shown in table 1, their average shares of the world's real gross domestic product over the period 1995-2019 are 3.1, 0.4, 0.3 percent, respectively.[4] The Brazilian economy is the only one to exceeds the world average of 0.52 percent. To get more insight into the size of the Brazilian economy, it is compared to more similarly sized economies.

[4] From a list of 189 economies, the Brazilian, Colombian, and Chilean ranks are 8, 42, and 35, respectively.

Table 2. Top economies by real economic size and trade statistics

Rank	Share of world GDP		Trade openness index		Exports (share of own GDP)		Imports (share of own GDP)		Exports (share of world exports)		Imports (share of world imports)	
1	USA	23.5	Singapore	342.4	Singapore	182.7	Singapore	159.7	USA	9.7	USA	13.6
2	Japan	9.4	Luxembourg	296.6	Luxembourg	163.4	Luxembourg	133.2	Germany	7.4	Germany	7.0
3	China	7.8	Malta	261.8	Malta	133.6	Malta	128.2	Japan	4.4	Japan	4.9
4	Germany	5.6	Ireland	177.6	Ireland	95.3	Timor-Leste	111.2	France	4.1	UK	4.4
5	France	4.2	Malaysia	151.2	Congo, Rep.	88.7	Marshall Islands	103.6	UK	4.0	France	4.2
6	UK	3.9	UAE	146.2	Bahrain	84.9	Kiribati	99.5	Italy	3.3	Italy	3.3
7	Italy	3.5	Bahrain	145.6	Malaysia	83.3	Lesotho	85.6	Netherlands	3.2	Netherlands	3.0
8	Brazil	3.1	Belgium	145.6	UAE	81.4	Palau	84.7	Canada	3.1	Canada	2.9
9	Canada	2.4	Slovak Republi	144.2	Brunei	76.7	Ireland	82.3	South Korea	2.4	South Korea	2.5
10	India	2.3	Vietnam	143.6	Equatorial Guinea	74.8	Kyrgystan	81.4	Russia	2.2	Spain	2.2

The average share of the top 10 largest economies, found in table 2, is 6.6 percent, and the three largest economies, the Chinese, Japanese, and American economies, respectively account for 7.8, 9.4, and 23.5 percent of the world's real economy. The Brazilian economy accounts for a much larger share of the world's economy than average economies, yet it is considerably smaller than the world's largest economies. How can it then be labelled? Is it a small economy? It most definitely is not. In their analysis of changes in the price of oil in Eurozone economies, Raduzzi and Ribba (2019) refer to Italy, a similarly sized economy, being a *medium economy*. The same nomenclature is adopted in this paper and as such, the Brazilian economy is considered medium-sized.

What does economic size illustrate with regards to understanding the context of the economies under study? Based solely on the average share of the world economy over the period 1995-2019, the Chilean and Colombian economies are average in size and that of Brazil is considerably larger than average. This could indicate that assumption (1) is a strong assumption for the latter. However, the picture is incomplete since the extent to which these economies are open to and engage in trade must also be discussed before putting forth a judgment.

3.2 International trade

All three economies under study engage in trade. To get a general idea of how much trade they conduct in relation to their real gross domestic product, the average value for a trade openness index is computed.[5] On average, the index for the 159 economies in the list is 84.0[6], while those for the economies of Chile, Colombia, and Brazil, in table 1, are 19.9, 33.3, and 63.0, respectively.[7] This trade openness index only illustrate how much an economy engages in trade in relation to its own real gross domestic product but gives no indication of whether an economy is more outward or inward oriented, nor how much weight its trade has in the global economy. Nonetheless, these figures demonstrate that all three economies engage in international trade and that they are below average in terms of their general openness to trade in relation to their real economies, especially in the Colombian and Brazilian cases which are among the least open economies of the world.

Table 1 suggests that the Colombian and Brazilian economies are not relatively more inward or outward oriented in terms of the individual weight of real exports and real imports relative to real gross domestic product. On the other hand, the Chilean economy is more outward oriented, with its real exports accounting for about 10 percent more of its real gross domestic product than its real imports.

On average during the period under study, an economy's real exports and imports account for 0.55 and 0.54 percent of the global economy's real exports and imports, respectively. As shown in table 1, the real exports of the Brazilian, Colombian, and Chilean economies account for 1.17, 0.25, and 0.43 percent of global exports, and real imports account for 1.15, 0.28, and 0.32 percent,

[5] The index is computed as follows: ((real exports + real imports)/real gross domestic product)*100. The mean value is for the period 1995-2019.

[6] This index implies that on average over the period 1995-2019, real exports and imports have a value equal to 84 percent of the economy's real gross domestic product.

[7] The Chilean, Colombian, and Brazilian ranks are 105, 150, and 159, respectively. Exports and imports as shares of national GDP were also individually computed and yield nearly the same rankings as the trade openness index.

respectively.[8] The Brazilian economy, which is above average in size, is also above average in terms of the weight of its exports and imports as shares of those of the global economy, but it is still not as far above average as other medium-sized and large economies. The other two do not appear to weigh much in global trade.

With regards to the assumptions, given that all three economies are not very open and do not have a lot of weight in global trade flows, then their influence on the world economy could be weak, implying that assumption (1) is likely not a strong one in the Chilean and Colombian cases. In the Brazilian case, to err on the side of caution, it is still considered a strong assumption.

3.3 Exports and imports of oil

As illustrated in table 2, over the period 1995-2016, the top ten exporters and importers of crude oil account for an average of 65.7 and 67.5 percent, respectively, of the world's total exports and imports of crude oil. OPEC members collectively account for 53.3 and 0.75 percent of exports and imports, respectively. The world average for exports and imports, respectively, is 1 and 0.8 percent.

Over this period, the Chilean economy does not export crude oil, and its imports account for an average of 0.43 percent of world's total oil imports. The Colombian and Brazilian economies account for 1.14 and 0.78 percent, respectively. The Chilean, Colombian, and Brazilian average shares of the world's total imports of oil are 0.43, 0.2, and 1 percent, respectively. All three economies are under the world oil import average, and the Colombian economy is the only one which surpasses the world oil export average. These three economies are also quite far from the averages of the largest exporters and importers of oil and are all dwarfed in comparison to the

[8] From a list of 159 economies, the Brazilian, Colombian, and Chilean exports rank are 22, 53, and 40, and their imports rank 18, 50, 47, respectively.

OPEC members. Overall, none of these South American economies are large importers or exporters of crude oil during the period under study. Thus, they likely cannot individually exert much influence on global demand and supply conditions of oil. This implies that assumption (2) is likely not a strong assumption to hold for all three economies.

Table 3. Average shares of world's largest exporters and importers of crude oil (1995-2016)

Rank	Exports		Imports	
1	Saudi Arabia	16.67	USA	21.49
2	Russia	10.38	Japan	9.56
3	Norway	5.48	China	7.34
4	UAE	5.47	South Korea	5.79
5	Iran	5.43	India	5.45
6	Nigeria	5.19	Germany	5.00
7	Venezuela	4.79	Italy	3.78
8	Iraq	4.32	France	3.73
9	Mexico	4.16	Spain	2.84
10	Canada	3.85	Netherlands	2.55

Given all stylized facts which are presented, it appears that assumptions (1) and (2) should hold, although (1) might be a strong assumption for the Brazilian economy. Overall, it appears that given the general economic reality of all three economies under study, a shock to the price of oil can be treated as pre-determined for all three.

4. Econometric framework

4.1 Structural VARs

The models estimated in the present paper hold the general form:

$$Y_t = \delta + \beta_1 Y_{t-1} + \cdots + \beta_q Y_{t-q} + \omega_t \quad (1)$$

The error terms for all models are such that $\omega_t = C\varepsilon_t$ where ε_t is a vector of structural shocks which are uncorrelated where $E(\varepsilon_t \varepsilon_t') = I$, and the matrix C is a lower triangular impact matrix. Since the matrix C is derived from the reduced-form VAR models' covariance matrices via Cholesky decomposition, then there is a Cholesky ordering of the variables. Hence, the variables contained in the vector of endogenous variables are ordered from least endogenous to most endogenous in such a manner that that the least endogenous variable is the first to respond to a shock and the following variables respond according to the imposed sequence.

The main model specification, referred to as specification 1, has the vector of endogenous variables $Y_{1,t}' = [\, o_t \;\; e_t \;\; y_t \;\; p_t \;\; i_t]$, where o_t is the real price of oil, e_t is the real effective exchange rate, y_t is the real gross domestic product, p_t is the inflation rate, and i_t is the overnight interbank interest rate. Given the assumption that the price of oil is pre-determined, it is ordered as the first, and least endogenous, variable. The ordering implies that a shock is first imposed on the price of oil, which then influences international trade activities. These variations are captured by the local currency's demand conditions, proxied by changes in the real effective exchange rate. Following this is a response from real gross domestic product which is influenced by either a demand-side or supply-side contraction, or both. Then, the inflation rate responds if there are changes in consumer prices. Finally, the overnight interbank interest rate responds to changes in overall economic conditions.

This ordering is inspired by the work of Raduzzi and Ribba (2020) who, when modeling small and *medium* eurozone economies, include oil prices first, immediately followed by some aggregate Euro-area variables, the difference between the Euro overnight index average, and the Federal Funds rate. Unfortunately, there is no equivalent aggregate South American data available. These variables are followed by the nominal EUR-USD nominal exchange rate, which is replaced

by the real effective exchange rate in the present paper. This variable should capture more variations in international trade activities than a single nominal exchange rate. The last variables are prices and output, but since the framework in the present paper assumes that income transfer between economies can occur due to changes in international trade activities, then the output variable is placed immediately after the exchange rate variable. The inflation rate is placed next to capture pass-through to consumer prices from the initial shock only after aggregate production responds (which includes goods and services produced which consumers purchase afterwards). Finally, the present paper assumes that financial intermediaries will respond (captured by the interbank rate) to the initial shock only after both national variables respond (the real economy and consumer prices). Changes in national variables correspond to a change in the general economic conditions to which these intermediaries are assumed to respond.

Several alternative model specifications are used to test the robustness of the main responses by either changing the ordering of the endogenous variables or by substituting a variable for a related one. Model specification 2, $Y'_{2,t} = [\, o_t \;\; y_t \;\; p_t \;\; i_t \;\; e_t]$, consists of a change in ordering of endogenous variables. Specification 3 substitutes the real effective exchange rate for real exports of goods in the local currency. Its vector of endogenous variables holds the form $Y'_{3,t} = [\, o_t \;\; x_t \;\; y_t \;\; p_t \;\; i_t]$, where x_t is real exports of goods. Specification 3's vector of endogenous variables is $Y'_{4,t} = [\, o_t \;\; e_t \;\; u_t \;\; p_t \;\; i_t]$, where u_t is the unemployment rate. Finally, specification 4's vector of endogenous variables is $Y'_{5,t} = [\, o_t \;\; e_t \;\; m_t \;\; p_t \;\; i_t]$, where a total manufacturing index is denoted by m_t. All specifications in the present paper, except for those of the Brazilian economy, are separately estimated using both the core and headline inflation rate, with other variables adjusted for the respective consumer price index.[9]

[9] Brazilian models are the exception since no freely accessible core consumer price index data could be found.

All model specifications are estimated via Ordinary Least Squares. To determine the optimal number of lags, Akaike, Bayesian, Hannan-Quinn, and Final Prediction Error information criteria tests are conducted on each model specification. In each case, the most prevalent and smallest suggested number of lags is imposed. Impulse response functions and error bands are computed via 10,000 bootstrapped residual-resampling replications, with 95 percent confidence intervals. The impulse responses and forecast error variance decompositions are for a horizon of 5 years, or 20 quarters.

An important property of Ordinary Least Squares estimates, emphasized and illustrated by Lipovetsky & Conklin (2001), is the that they should be interpreted as weighted averages of their sub-samples. In relation to the time-series in the present paper, this implies that structural break responses which deviate from their full-sample counterparts do not invalidate the full-sample responses. It simply means that the full-sample responses can be interpreted as the most general results for the time horizon under study and that its sub-samples are a more precise look into how the data behave in specific time horizons.

4.2 Data

The South American economies and time-series under study were chosen in part because they are large South American economies, but they also happen to be the only ones with freely accessible time-series which are long enough to be modeled using VAR models. All series are retrieved in levels, nominal format, non-seasonally adjusted, and are transformed as follows: (1) X-13-ARIMA-SEATS is used to remove seasonal effects when present in a series. (2) Series which were originally in US dollars are converted into the local currency using spot exchange rates.[10] (3)

[10] Series originally in USD are the WTI world price of oil, and Colombian and Brazilian exports of goods.

Nominal series are converted into real series using the core consumer price index of each economy, or its headline counterpart for model specifications which involve the headline inflation rate.[11] (4) All series are tested for stationarity using Augmented Dickey-Fuller (ADF) and ADF-GLS tests. Following these tests, all series are log-differenced, except for the interbank rates and unemployment rates. This step turns the log-differenced series and associated results into approximate growth rates. (5) Inflation rates are annualized by simply multiplying them by four.

Chilean series from the OECD include core and headline consumer price indices, interbank overnight lending interest rate, nominal exports of goods, unemployment rate, total manufacturing index, and local currency to US dollar exchange rate. The real effective exchange rate is from the Bank for International Settlements, and the nominal gross domestic product is from the *Banco Central de Chile* (Chile's central bank). After transformations, all Chilean series have the range 1996Q2-2020Q1, except for the core consumer price index whose range is 1999Q2-2020Q1.

Colombian series for core and headline consumer price indices, total manufacturing index, and local currency to US dollar exchange rate are from the OECD, and the real effective exchange rate is from the Bank for International Settlements. The interbank overnight lending interest rate, nominal exports of goods, and unemployment rate are from the *Banco de la República* (Colombia's central bank). Nominal gross domestic product is from the *Departamento Administrativo Nacional de Estadística* (Colombia's national statistics department). After transformations, the nominal gross domestic product and unemployment rate have the ranges 2005Q2-2020Q1 and 2001Q2-2020Q1, respectively. All the others have the range 1995Q2-2020Q1.

Brazilian series from the OECD are the nominal gross domestic product, headline consumer price index, local currency to US dollar exchange rate, total manufacturing index,

[11] Nominal series are WTI oil price, exports of goods, and gross domestic product.

unemployment rate, nominal exports of goods, and interbank overnight lending interest rate. The real effective exchange rate is from the Bank for international settlements. All series range from 1997Q2-2020Q1 after transformations, except for the unemployment rate whose range is 1997Q2-2015Q3.

The world price of oil is proxied by the global WTI price series from the International Monetary Fund. Its range after transformations is 1995Q2-2020Q1, hence it accommodates all analyses conducted.

5. Main results

In this section, specification 1's impulse responses and forecast error decompositions are discussed in detail.[12]

5.1 Impulse responses

Chilean responses are found in figure 1. An unanticipated 10 percentage points increase in the price of oil leads to a contraction in Chilean real gross domestic product, the largest of which occurs 2 quarters following the initial shock and represents a 0.18 percentage points decrease in real economic growth and is followed by a second contractionary quarter. This suggests that following a large, unanticipated increase in the price of oil, the Chilean economy could fall into a recessionary state. The core inflation rate's largest response takes place immediately after the initial shock, representing a 0.4 percentage points increase. There is an overlap of real economic contraction and core inflation rate increase on the second quarter following the initial shock, which implies that a brief period of stagflation takes hold of the Chilean economy.

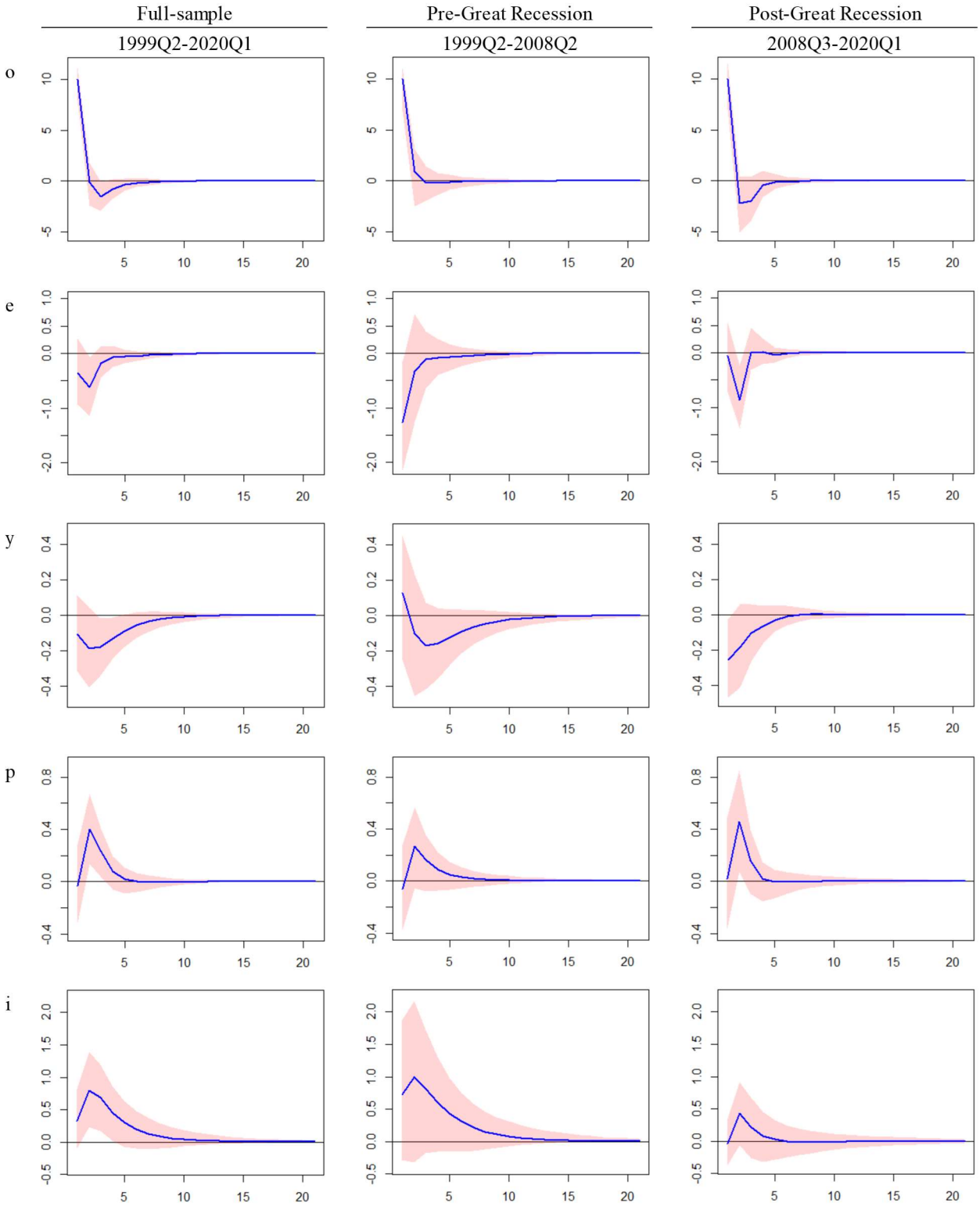
[12] Recall this specification's vector of endogenous variables: $Y'_{1,t} = [\, o_t \;\; e_t \;\; y_t \;\; p_t \;\; i_t]$.

To verify the extent to which the main results are consistent across time, the time-series under study are separated by a structural break. The source of this break is assumed to be the onset of the Great Recession whose start is assumed to be the two contractionary quarters which define the United States' recession (last two quarters of 2008). These quarters are at the beginning of the post-structural break sample.

For the Chilean economy, the structural break yields the sub-samples 1999Q2-2008Q2 and 2008Q3-2020Q1. The resulting responses, found in figure 1, are generally consistent in shape with each other and the full-sample responses. The only statistically significant responses are from the pre-break real gross domestic product contraction and post-break real effective exchange rate contraction and core inflation rate increase. Given these observations, it is important to recall that the main, full-sample responses are weighted averages their sub-sample counterparts.

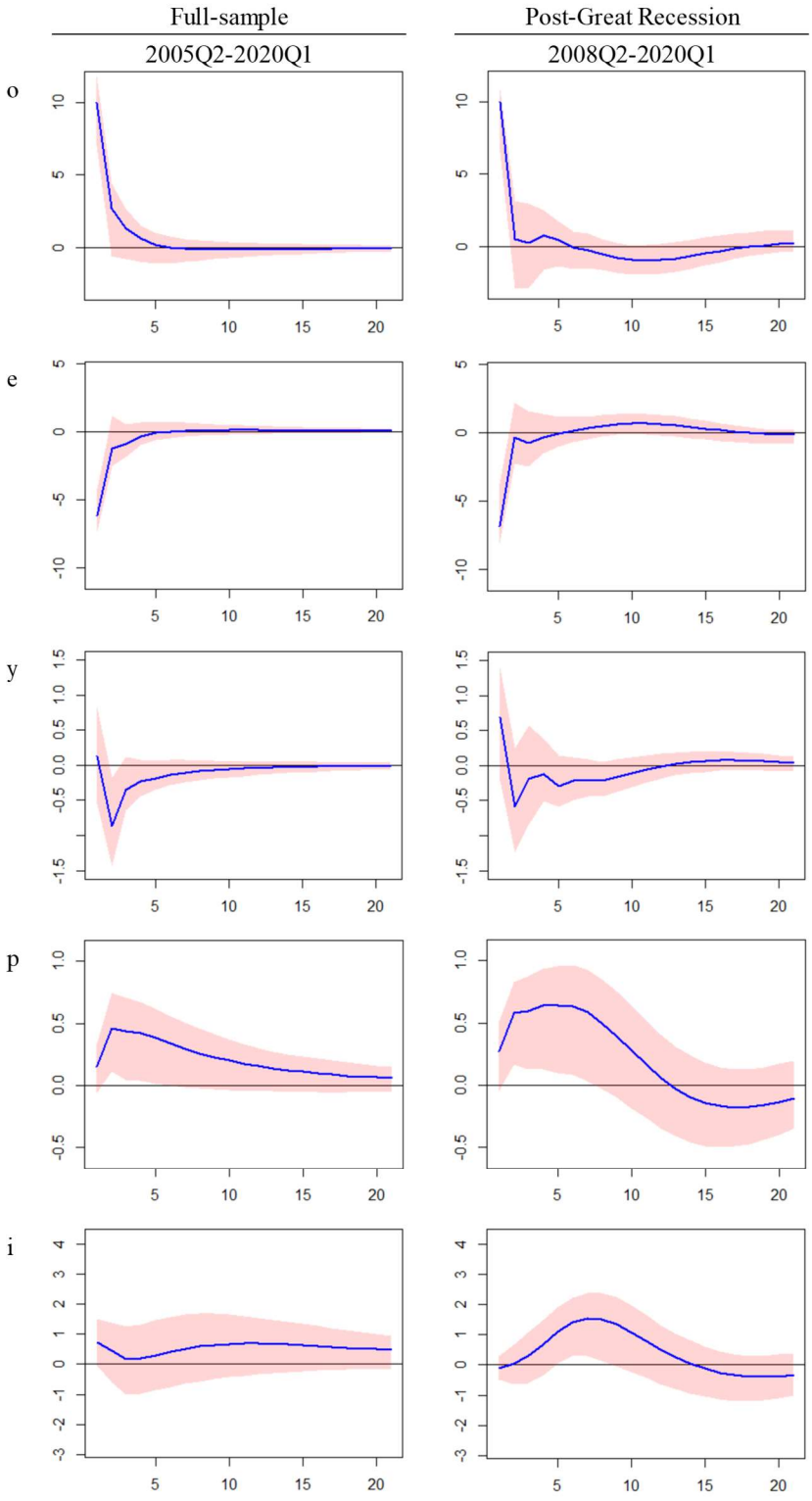
Colombian responses are found in figure 2. Colombian real gross domestic product responds to a 10 percentage points unanticipated increase in the price of oil by contracting for two consecutive quarters, signalling the presence of recessionary effects. The largest contraction occurs 2 quarters following the initial shock and represents a 0.87 percentage points decrease in real economic growth. The Colombian core inflation rate increases for 4 quarters, starting immediately following the initial shock, which is also the point at which the largest response occurs. This largest response represents a 0.46 percentage points increase in core inflation and coincides with real economic contraction, suggesting the presence of stagflation.

Figure 1. Chilean impulse responses to an unexpected 10 percent increase in the price of oil



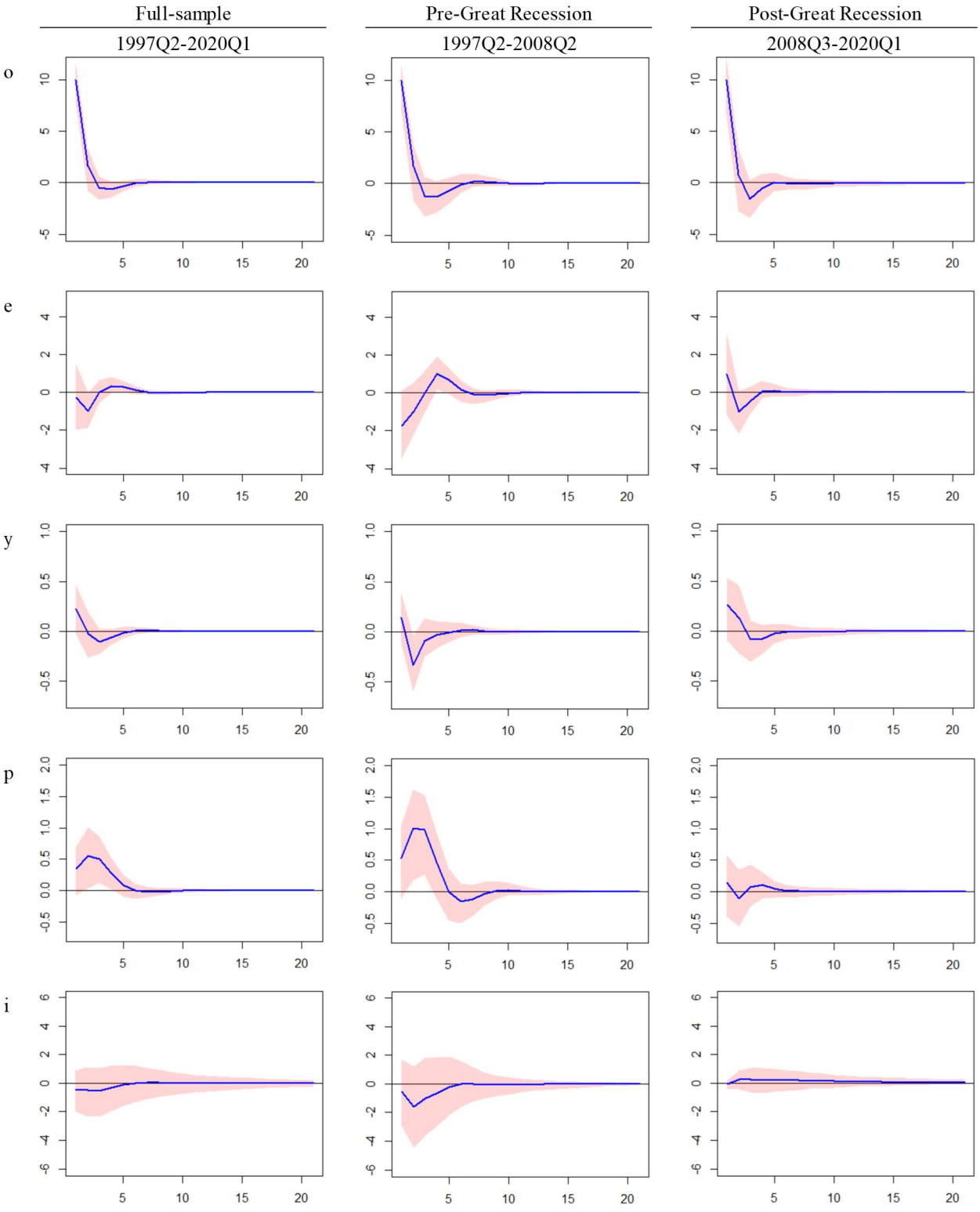
Note: Blue lines are impulse responses and red shaded areas are 95 percent confidence intervals.

Figure 2. Colombian impulse responses to an unexpected 10 percent increase in the price of oil



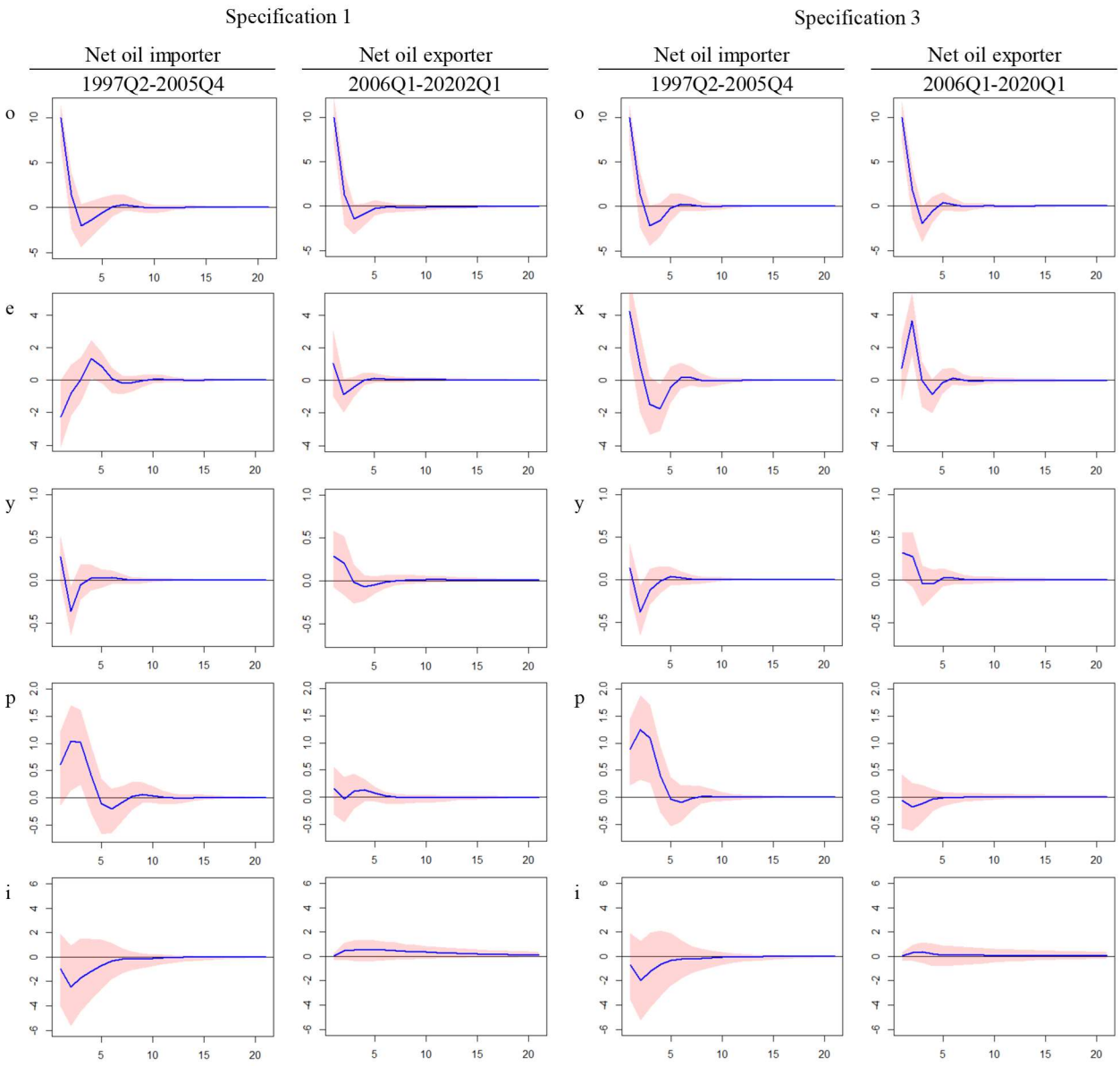
Note: Blue lines are impulse responses and red shaded areas are 95 percent confidence intervals.

Figure 3.1. Brazilian impulse responses to an unexpected 10 percent increase in the price of oil



Note: Blue lines are impulse responses and red shaded areas are 95 percent confidence intervals.

Figure 3.2. Brazilian impulse responses to an unexpected 10 percent increase in the price of oil



Note: Blue lines are impulse responses and red shaded areas are 95 percent confidence intervals.

The full-sample is too short to analyze the pre-Great Recession sub-sample and as such, only the post-break sub-sample (2008Q3-2020Q1) is considered. The responses, found in figure 2, are broadly consistent with their full-sample counterparts and include statistically significant inflationary effects and increase in the interbank rate.

The main set of Brazilian responses are illustrated in figure 3.1. Following an unanticipated 10 percentage points increase in the price of oil, Brazilian real economic growth remains unaffected, but inflationary effects are present for the three quarters following the initial shock. The largest effect on inflation occurs immediately after the shock and represents a 0.5 percentage points increase. Besides being unaffected following a shock to oil prices, a stark difference in the Brazilian responses is a statistically significant growth in the real effective exchange rate as opposed to a statistically significant decrease or null effect. This response remains statistically significant in the structural break exercise for the pre-break sample responses.

The sub-samples from the pre- and post-Great Recession (1997Q2-2008Q2 and 2008Q3-2020Q1, respectively) yield responses which are somewhat consistent across sub-samples and with the full-sample. Confidence intervals aside, a noteworthy peculiarity is the real effective exchange rate and interbank rate which both respond in opposite directions before and after the break. To verify whether this might be related to the change in the Brazilian economy's position from a net oil importer prior to 2006 to a net exporter afterwards, a second break is tested with different sub-samples (1997Q2-2005Q4 and 2006Q1-2020Q1, respectively). These responses, which make use of specification 1, are found in figure 3.2. They are nearly identical to the main set of responses,

which could suggest that the true change in coefficient estimates could be due in great part to becoming a net exporter of oil. These responses, however, are mostly statistically insignificant.[13]

To get more precise insight into how oil exports might relate to these responses, the last structural break exercise is repeated but replaces the real effective exchange rate (specification 1) with real exports of goods (specification 3). The responses from figure 3.2 show that as a net oil importer, the Brazilian economy experiences a statistically significant decrease in real exports of goods and gross domestic product, and an increase in the headline inflation rate. As a net oil exporter, there is a statistically significant increase in real exports of goods. The latter responses could be a result of the increase in the price of oil such that higher oil prices simply increase the total real value of exports which include crude oil and oil-related outputs, without any statistically significant change in other variables. When the economy is a net oil exporter, Brazilian real gross domestic product remains unaffected by an unexpected increase in oil prices.

As a net oil importer, the story is very different, as illustrated in figure 3.2. Higher oil prices might result in overall higher input costs, which decreases the demand for Brazilian exports, resulting both a decrease in aggregate production (or negative real economic growth) and an increase in consumer prices. Since the last two occur simultaneously, this suggests the presence of stagflation. The contraction in real economic growth is brief, lasting only one quarter immediately after the shock, whereas the inflationary response lasts for the three quarters following the shock and is quite elevated with a maximum effect representing a 1.2 percentage point increase. As a net oil importer, the Brazilian economy is sensitive to changes in the price of oil, and the channel through which it exerts its influence could be through a decrease in exports. Interestingly, it

[13] It is important to note that the Brazilian exchange rate has been free-floating since early 1999 (Shikida et al., 2011). This implies that the first few observations from the pre-Great Recession sample correspond to a period of managed, as opposed to free-floating, rate.

appears that despite experiencing negative growth of real exports of goods, there is a demand for the local currency which is substantial enough for it to be followed by statistically significant appreciation via higher real effective exchange rate.

Impulse responses for the three economies under study suggest that over their full-samples, the Chilean and Colombian economies experience real economic contraction, whereas the Brazilian economy remains unaffected. There is also evidence of pass-through to consumer prices in all three economies, illustrated via an increase in core inflation rates for the Chilean and Colombian economies, and an increase in headline inflation rates for the Chilean and Brazilian economies.

5.2 Forecast error variance decompositions

Analyzing forecast error variance decompositions can help quantify the extent to which unexpected movements of oil prices influence business cycle fluctuations. Table 4.1 shows that in the Chilean case, oil price innovations account for some shares of the forecasted error variance of the system's variables, with those most influenced being core inflation and the interbank rate. The largest shares of these two which are accounted for by oil price innovations are 9.3 and 8.7 percent for long-run, 20 quarters (5 years) forecasts, respectively. Overall, the Chilean economy's business cycle fluctuations appear to be only somewhat sensitive to unexpected movements in oil prices.

The Colombian economy is a very different case. Oil price innovations account for most of the forecast error variance of the real effective exchange rate. Table 4.1 illustrates how these innovations account for 73 percent in a 1-step ahead forecast and drop to 63.3 percent over the long-run. Forecast error variances of the gross domestic product and core inflation rate are also influenced to a large degree by oil price innovations, which account for a maximum of 13.5 and

26.7 percent over the long-run, respectively. The Colombian economy's business cycle fluctuations seem sensitive to unexpected oil price movements, especially the real effective exchange rate which derives most of its variability from oil price innovations. The latter could be due to changes in foreign demand conditions of the local currency from movements in the price of oil.

Table 4.1. Share of forecast error variance attributable to innovations of the following variables at different horizons

		Chile					Colombia					Brazil				
Forecast error for:	Horizon	o	e	y	p	i	o	e	y	p	i	o	e	y	p	i
o	1	100	0	0	0	0	100	0	0	0	0	100	0	0	0	0
	2	78.4	11.3	6.9	2.5	0.9	88.8	1.8	9.1	0.3	0.0	94.8	2.3	1.0	1.7	0.1
	5	72.2	10.5	12.1	4.1	1.0	87.1	2.0	10.2	0.7	0.0	91.6	4.2	1.6	2.2	0.5
	10	72.1	10.5	12.1	4.2	1.0	86.6	2.0	10.3	1.0	0.1	91.3	4.2	1.6	2.2	0.6
	20	72.1	10.5	12.1	4.2	1.0	86.3	2.0	10.3	1.3	0.1	91.3	4.2	1.6	2.3	0.7
e	1	1.6	98.4	0	0	0	73.0	27.0	0	0	0	0.4	99.6	0	0	0
	2	6.0	89.6	4.3	0.1	0.1	65.3	23.5	10.7	0.4	0.0	4.3	86.4	2.9	6.4	0.1
	5	6.3	87.5	4.8	0.3	1.0	64.5	23.0	11.5	0.8	0.1	4.8	82.1	2.9	9.7	0.5
	10	6.4	87.1	4.9	0.3	1.3	64.0	22.8	11.6	1.4	0.3	4.8	81.8	2.9	9.7	0.8
	20	6.4	87.1	4.9	0.3	1.3	63.6	22.6	11.5	1.9	0.3	4.8	81.7	2.9	9.7	0.9
y	1	1.1	2.4	96.4	0	0	0.3	13.8	85.9	0	0	5.2	6.8	88.0	0	0
	2	3.3	2.4	91.7	2.2	0.5	10.8	13.6	74.5	1.2	0.0	4.7	13.2	80.4	1.8	0.0
	5	6.0	2.0	83.0	5.7	3.2	13.0	13.7	71.1	2.1	0.0	5.7	14.7	77.7	1.9	0.0
	10	6.2	2.0	81.4	6.0	4.4	13.4	13.6	70.3	2.6	0.0	5.7	14.7	77.6	1.9	0.0
	20	6.2	2.0	81.3	6.0	4.5	13.5	13.6	70.2	2.7	0.0	5.7	14.7	77.6	1.9	0.0
p	1	0.1	4.5	16.5	78.9	0	2.9	1.8	1.0	94.2	0	3.9	1.4	1.6	93.1	0
	2	7.6	3.7	15.8	72.9	0.0	14.5	2.4	2.2	80.8	0.0	8.6	13.0	1.9	76.5	0.1
	5	9.4	4.1	15.1	70.8	0.6	23.5	2.9	1.2	72.2	0.2	13.4	16.3	2.7	67.5	0.1
	10	9.3	4.1	15.4	70.5	0.7	26.4	2.8	0.9	69.5	0.4	13.4	16.3	2.7	67.5	0.1
	20	9.3	4.1	15.4	70.4	0.7	26.7	2.8	1.0	68.9	0.6	13.4	16.3	2.7	67.5	0.1
i	1	1.6	0.1	0.5	10.2	87.6	9.4	0.9	3.0	13.7	72.9	0.4	10.8	0.4	0.7	87.6
	2	6.7	0.2	0.3	12.8	80.0	5.4	0.6	22.6	19.1	52.4	0.6	7.6	0.2	1.6	90.0
	5	9.0	0.4	2.0	12.9	75.7	2.6	0.5	29.1	31.6	36.3	0.6	7.1	0.1	5.6	86.6
	10	8.7	0.5	3.6	12.4	74.9	4.2	0.8	25.2	42.8	26.9	0.5	7.8	0.2	7.1	84.5
	20	8.7	0.5	3.6	12.3	74.9	7.5	1.1	20.7	49.0	21.6	0.4	7.9	0.2	7.4	84.1

Note: The Chilean, Colombian, and Brazilian results are derived from the periods 1999Q2-2020Q1, 2005Q2-2020Q1, and 1997Q2-2020Q1, respectively. Zero is denoted by "0", whereas a very small number that is larger than zero is denoted "0.0".

Table 4.2. Shares of forecast error variance attributable to innovations of the following variables at different horizons for the Brazilian economy

		Net oil importer					Net oil exporter				
Forecast error for:	Horizon	o	e	y	p	i	o	e	y	p	i
o	1	100	0	0	0	0	100	0	0	0	0
	2	85.1	0.2	11.3	3.2	0.2	84.4	13.1	1.3	1.1	0.2
	5	82.1	1.3	11.4	4.9	0.3	81.3	13.4	1.8	3.0	0.4
	10	81.8	1.4	11.5	4.9	0.3	80.0	13.3	1.9	4.3	0.6
	20	81.8	1.4	11.5	4.9	0.3	79.4	13.2	1.9	4.9	0.6
e	1	20.2	79.8	0	0	0	6.4	93.6	0	0	0
	2	18.2	66.3	2.9	12.6	0.1	9.4	90.5	0.0	0.1	0.0
	5	20.8	54.9	8.8	12.9	2.6	10.2	89.1	0.2	0.4	0.1
	10	20.6	54.4	9.1	13.0	2.9	10.2	88.2	0.2	1.2	0.3
	20	20.6	54.4	9.1	13.0	2.9	10.1	87.7	0.3	1.6	0.3
y	1	8.8	4.9	86.3	0	0	7.2	15.2	77.5	0	0
	2	20.8	4.1	71.2	2.0	1.9	8.1	23.9	62.7	5.3	0.0
	5	20.8	4.7	70.2	2.3	2.0	7.5	26.6	54.6	11.3	0.0
	10	20.9	4.7	70.1	2.3	2.1	7.5	26.5	54.4	11.5	0.1
	20	20.9	4.7	70.1	2.3	2.1	7.5	26.4	54.2	11.8	0.2
p	1	9.0	0.0	10.9	80.1	0	1.3	0.2	6.1	92.4	0
	2	20.3	6.9	15.1	53.6	4.1	0.9	2.5	4.2	92.4	0.0
	5	28.6	6.8	14.4	42.6	7.6	1.8	3.7	4.6	89.8	0.0
	10	28.7	7.1	14.4	42.1	7.7	1.9	3.7	4.6	89.7	0.1
	20	28.7	7.1	14.4	42.1	7.7	1.9	3.7	4.7	89.6	0.1
i	1	1.1	23.9	0.2	0.1	74.7	0.1	0.0	0.7	25.6	73.6
	2	5.2	21.9	1.3	0.6	71.1	4.9	1.2	3.0	52.7	38.2
	5	6.6	20.2	2.0	0.5	70.8	6.0	1.9	5.6	68.5	18.0
	10	6.5	20.2	2.1	0.5	70.7	6.3	1.9	6.7	71.4	13.7
	20	6.5	20.2	2.1	0.5	70.7	6.4	1.9	6.9	72.0	12.7

Note: These results are derived from the periods 1997Q2-2005Q4 (net oil importer) and 2006Q1-2020Q1 (net oil exporter). Zero is denoted by "0", whereas a very small number that is larger than zero is denoted "0.0".

Over its full-sample, the Brazilian economy's business cycle fluctuations do not appear highly sensitive to unexpected oil price movements. Only the inflation rate is noticeably sensitive, from table 4.1, for a one-step ahead forecast, 3.9 percent of its variability is explained by oil price innovations but grows to a more substantial 13.4 percent over the long-run. These results are from

two distinct periods of Brazilian trade and should be interpreted as a generalization of these two periods. However, given the different responses from some variables in these two periods, it is better to be cautious and assume these results to be weak evidence. For stronger evidence, the forecast error variance decompositions of its sub-samples for the periods as a net oil importer and exporter are also analyzed (1997Q2-2005Q4 and 2006Q1-2020Q1, respectively).

Table 4.2 illustrates these results and the difference in sensitivity of some variables to oil price innovations in both periods is quite large. As a net oil importer, unexpected oil price movements account for twice as much of the variability in the real effective exchange rate in comparison to when it is a net exporter. The long-run shares of variability accounted for by oil price innovations are 20.6 and 10.1 percent before and after becoming a net exporter of oil, respectively. As a net oil importer, the Brazilian real economy is also much more sensitive to movements in the price of oil, where unexpected movements in oil prices account for 8.8 percent of fluctuations in real economic growth for a 1-step ahead forecast and jump to 20.8 percent for all subsequent quarters. As a net exporter of oil, these figures are more modest, but still somewhat elevated where 7.5 percent of the variability of real growth in the long-run is derived from unexpected oil price changes. It is worth noting that in the latter oil trade position, the real effective exchange rate is a much larger determinant of real growth variability, starting at 15.2 and jumping to 26.4 percent over the long-run. The inflation rate's case is starkly different in both periods. As a net importer of oil, 28.7 percent of the inflation rate's long-run forecast error variance is attributable to unexpected oil price movement, which starts only at 9 percent for a 1-step ahead forecast. As a net oil exporter, the equivalent figure does not go beyond 2 percent, with the long-run figure stabilizing at 1.9 percent. Overall, when in a position of net oil exports, the Brazilian

business cycle is comparatively less sensitive to oil price innovations than when it is in a position of net oil imports.[14]

6. Alternative specifications

In this section, the main variables of interest, gross domestic product and the inflation rate, are tested for their robustness. This is done by either changing the ordering[15] of the endogenous variables or by replacing variables by related alternatives. The resulting impulse responses are compared to those of the main specification.[16] Robust results are those which do not differ much from those of the main specification.

All alternative Chilean responses, including those from the variables of interest and others, illustrated in figure 4, are highly consistent in shape and magnitude with those of the main specification. Real economic growth's maximum response occurs the quarter after the shock to oil and represents a contraction of -0.19 and -0.36 percentage points for specifications 1 and 3, respectively. These responses differ slightly in magnitude but are both statistically significant. For the inflation rate, the responses across specifications are immensely consistent, with the largest effects always occurring at the same quarter, remaining very near the main response's 0.4 percentage points increase, and remaining statistically significant across specifications.

[14] To verify how consistent the responses remain when straying from the preferred number of lags, the main specification is also estimated with four lags. This exercise is conducted for all three economies. The resulting responses are less stable in all cases, but consistent with the main responses. Another exercise is conducted for the Chilean and Colombian economies where the main specification is estimated using headline inflation instead of core inflation, and where all nominal variables are instead adjusted for core inflation. The responses are also consistent in shape with their core inflation counterparts, but the only statistically significant response across these two economies is the Chilean headline inflation rate, which experiences an increase. All Brazilian analyses only include headline inflation and nominal variables adjusted for headline inflation, hence there is no such analysis for this economy.

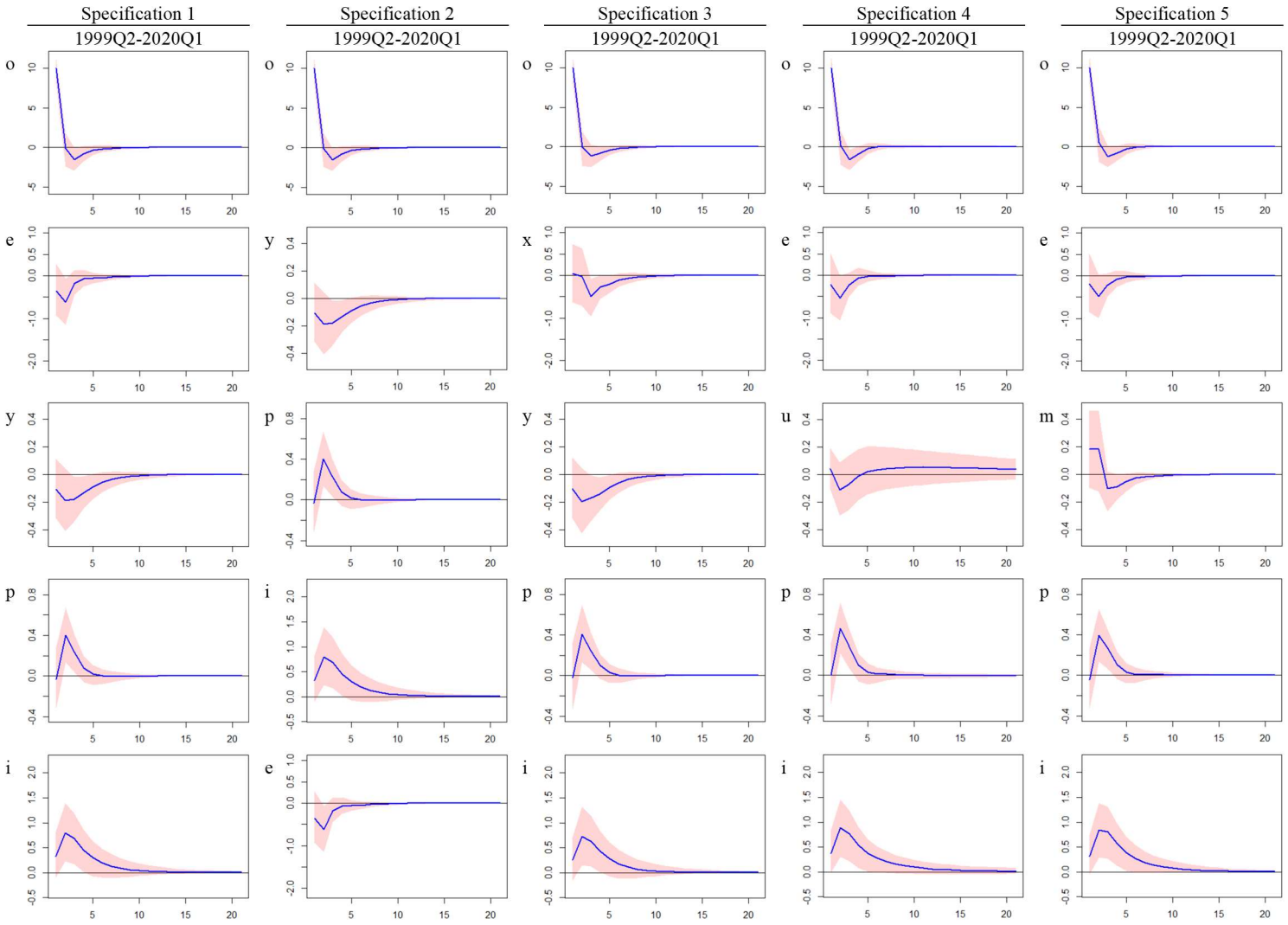
[15] For all economies, the results from a change in ordering (specification 2) are nearly the same as those of specification 1, with differences only occurring after around 14 decimal points for all variables.

[16] Recall the alternative specifications' vectors of endogenous variables: $Y'_{2,t} = [\, o_t \;\; y_t \;\; p_t \;\; i_t \;\; e_t]$, $Y'_{3,t} = [\, o_t \;\; x_t \;\; y_t \;\; p_t \;\; i_t]$, $Y'_{4,t} = [\, o_t \;\; e_t \;\; u_t \;\; p_t \;\; i_t]$, and $Y'_{5,t} = [\, o_t \;\; e_t \;\; m_t \;\; p_t \;\; i_t]$.

Specification 3, 4, and 5's largest inflation rate increase are 0.41, 0.46, and 0.39 percentage points, respectively. Since most responses from all variables appear consistent across specifications, then they are robust to changes in how real economic activity and international trade are defined in the model and to a slight change in ordering. This implies that following an unexpected 10 percent increase in the price of oil, there is very likely real economic contraction on the quarter following the shock to oil prices, although the exact magnitude is not clear since in both cases the estimates are not quite near each other. It is also likely the case that the inflation rate increases for two quarters, with a maximum increase reaching about 0.4 percentage points during the same quarter as the real contraction. This overlap in effects suggests that there could be a short period of stagflation which takes hold of the Chilean economy.

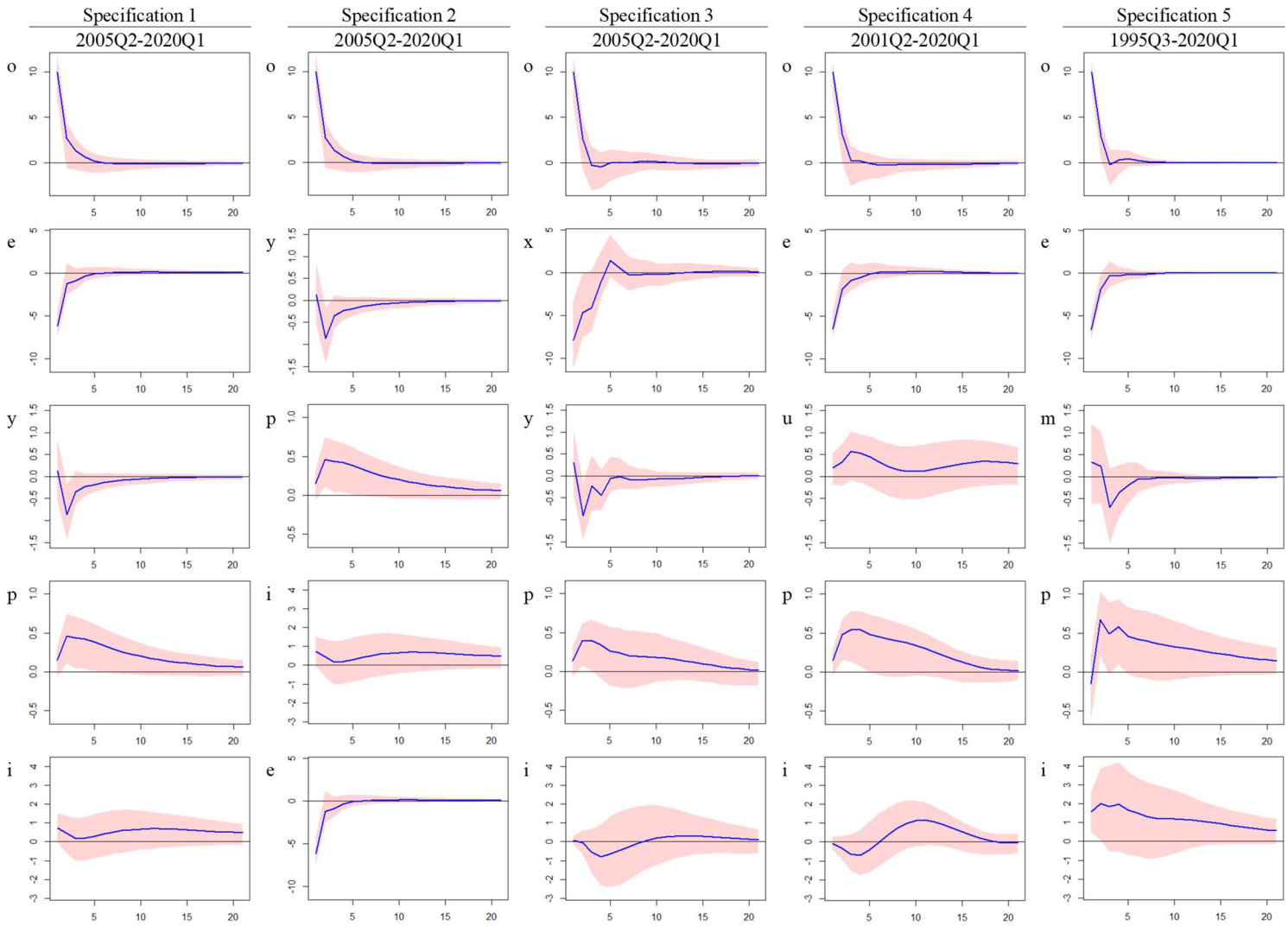
The Colombian alternative responses, except for those of specification 2, are less stable than their main specification counterparts, as illustrated in figure 5. Despite this, they remain consistent in shape and magnitudes, except for the interbank rate which diverges significantly across some specifications. Real gross domestic product's largest response, and only statistically significant one in both cases where it used, occurs immediately after the shock to oil in both specifications 1 and 3, representing 0.87 and 0.91 percentage points decreases, respectively. Overall, the inflation rate's responses are also consistent. Specification 1's largest inflation rate response occurs the quarter following the shock and has a magnitude of 0.46 percentage points. This same quarter's responses from the inflation rate for specifications 3, 4, and 5 represent 0.40, 0.48, and 0.67 percentage points increases, respectively. However, these responses are the largest only for specifications 1 and 5. Statistically significant increases in the inflation rate occur during quarters 1-3, 1-2, 1-2, and 1-3 following the shock in specifications 1, 3, 4, and 5, respectively. Since there is some noticeable consistency across specifications, the Colombian results appear to

Figure 4. Chilean impulse responses to an unexpected 10 percent increase in the price of oil



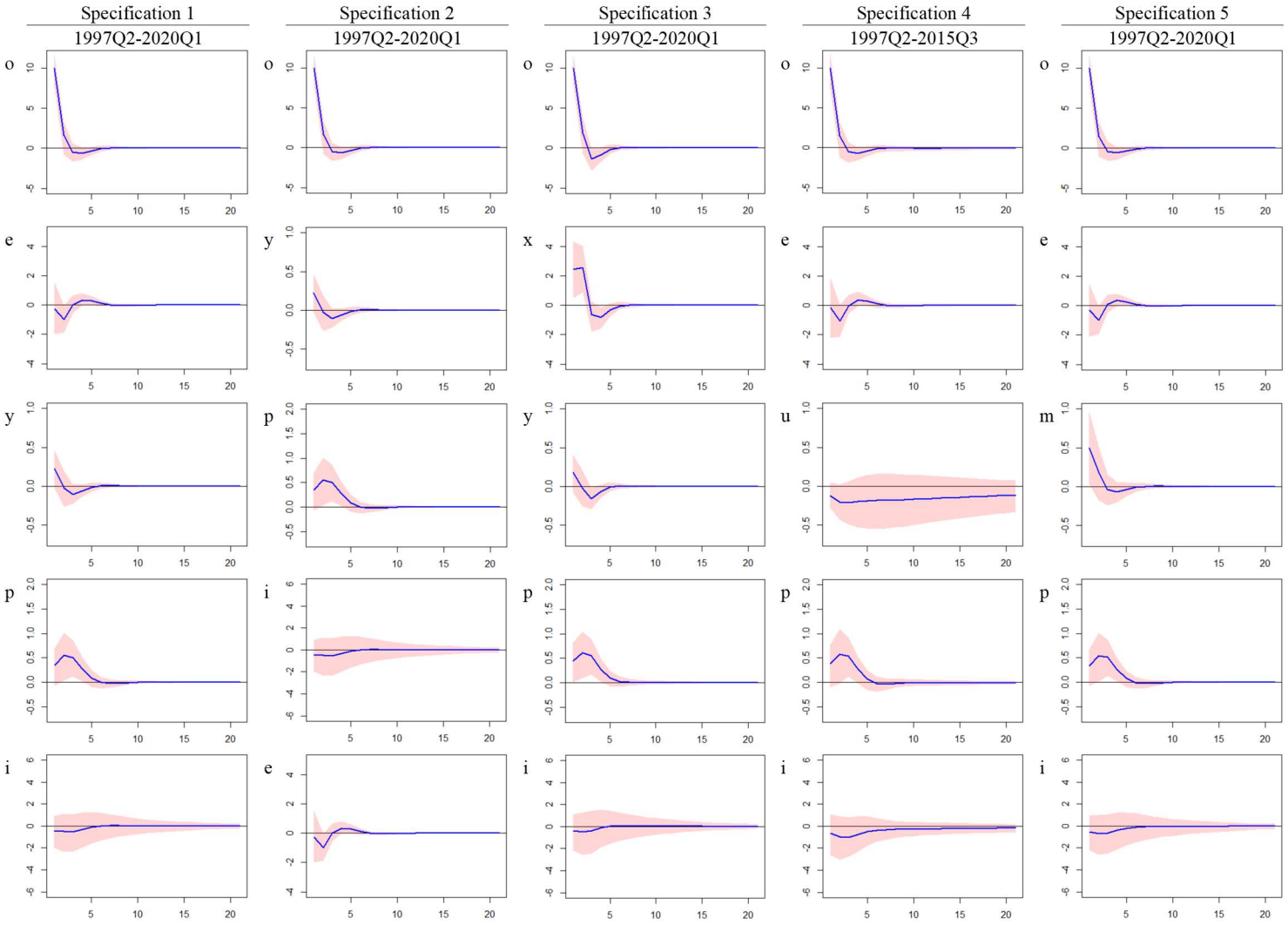
Note: Blue lines are impulse responses and red shaded areas are 95 percent confidence intervals.

Figure 5. Colombian impulse responses to an unexpected 10 percent increase in the price of oil



Note: Blue lines are impulse responses and red shaded areas are 95 percent confidence intervals.

Figure 6. Brazilian impulse responses to an unexpected 10 percent increase in the price of oil



Note: Blue lines are impulse responses and red shaded areas are 95 percent confidence intervals.

be robust to changes in how real economic activity and international trade are defined and to a small change in ordering. Also, since the responses from specifications 4 and 5 are derived from longer time series (2001Q2-2020Q1 and 1995Q2-2020Q1, respectively), then the inflation rate's robustness could reach back to 1995Q2. Hence, following an unexpected increase in oil prices, the Colombian economy could experience real economic contraction of around 0.87 percentage points during the quarter immediately following the initial shock, followed by an increase in its core inflation rate for two quarters, with a maximum increase of approximately 0.46 percentage points. The overlap in effects suggests that the Colombian economy could suffer from a brief period of stagflation.

As illustrated in figure 6, all Brazilian responses appear highly consistent in both shape and magnitudes across specifications. The largest responses for real gross domestic product in specifications 1 and 3, respectively, represent 0.11 and 0.16 percentage points decreases, where only the latter is statistically significant. The inflation rate's largest response for specification 1 is a 0.54 percentage points increase and occurs immediately after the shock to oil prices. The response during this same quarter for specifications 3, 4, and 5 represent increases of 0.61, 0.58, and 0.54 percentage points, respectively, but the latter two are not statistically significant. There is some divergence with regards to the length of time that the inflation rate increases with statistical significance. For specifications 1 and 3, increased inflationary effects occurs during the three quarters following the initial shock, and for 4 and 5 these effects occur only for the two quarters following the shock. Overall, the Brazilian responses are highly consistent, suggesting that the main responses from the two variables of interest are robust to changes in how real economic activity and international trade are defined and to a minor change in ordering. Hence, according to the main, full-sample specification, an unexpected positive shock to the price of oil does not result

in a change in the Brazilian real economic growth, but likely results in a period of increased headline inflation for three quarters, with a maximum increase reaching around 0.54 percentage points on the quarter following the shock.[17]

7. Conclusion

This paper analyzes the influence of an unexpected oil price increase on the Chilean, Colombian and Brazilian macroeconomies. The main contribution involves re-visiting South American economies which have not been studied at length. Different specifications are estimated to test for the robustness of the main results. The variables of interest, real gross domestic product and the inflation rate, are generally robust to changes in the number of lags, the manner in which real economic activity and international trade are defined, the ordering of variables, and sample periods.

This paper finds evidence that following an unexpected oil price increase for the full-sample analyses: (1) The Chilean and Colombian real economies contract for one quarter, while that of Brazil remains unaffected. (2) Core Chilean and Colombian inflation rates and headline Chilean and Brazilian inflation rates increase for no more than three quarters. (3) The business cycles of the Chilean and Brazilian economies are somewhat sensitive to unexpected oil price movements, while that of the Colombian economy is quite sensitive in comparison.

The economies under study in this paper, those of Chile, Colombia, and Brazil, and the time periods under study were chosen mostly due to data availability. As their available time-series

[17] The Chilean and Colombian specifications discussed in this section are estimated with core inflation and nominal variables are adjusted with the core consumer price index. They were also separately estimated with headline inflation and adjusted with a headline consumer price index. Overall, the responses from specifications which include headline inflation are consistent with their core inflation counterparts. All Brazilian specifications exclusively include the headline inflation rate and nominal variables are adjusted using the core consumer price index, hence there is no such analysis for this economy.

become longer, they could be revisited by researchers to obtain better estimates. Also, as more data becomes available for other South American economies, they could be studied to gain more insights on the effects of oil price shocks in this area of the world.

References

Abeysinghe, T., 2001. Estimation of direct and indirect impact of oil price on growth. Economics Letters, 73(2): 147–153.

Baumeister, C., Peersman, G., 2013. Time-varying Effects of Oil Supply Shocks on the US Economy. American Economic Journal, 5(4): 1–28.

Blanchard, O. J., Galli, J., 2007. The Macroeconomic Effects of Oil Shocks. Why are the 2000s So Different from the 1970s? In: International Dimensions of Monetary Policy, NBER Chapters, 373–421.

Brown, S. P. A., Yücel, M. K., 2002. Energy prices and aggregate economic activity: an interpretive survey. The Quarterly Review of Economics and Finance, 42(2): 193–208.

Burbidge, J., Harrison, A., 1984. Testing for the Effects of Oil-Price Rises using Vector Autoregressions. International Economic Review, 25(2): 459–484.

Castro, C., Jimenez-Rodriguez, R., 2017. Oil price pass-through along the price chain in the euro area. Energy Economics. Energy Economics, 64: 24–30.

Cavalcanti, T., Jalles, J. T., 2013. Macroeconomic effects of oil price shocks in Brazil and in the United States. Applied Energy, 104: 475–486.

Chuku, A. C., 2012. Linear and asymmetric impacts of oil price shocks in an oil-importing and -exporting economy: the case of Nigeria. OPEC Energy Review, 36(4): 413–443.

Clark, T. E., Terry, S. J., 2010. Time Variation in the Inflation Passthrough of Energy Prices. Journal of Money, Credit and Banking, 42(7): 1419–1433.

Cunado, J., Perez de Gracia, F., 2005. Oil prices, economic activity and inflation: evidence for some Asian countries. The Quarterly Review of Economics and Finance, 45(1): 65–83.

Cunado, J., Perez de Gracia, F., 2003. Do oil price shocks matter? Evidence for some European countries. Energy Economics, 25(2): 137–154.

Darby, M. R., The Price of Oil and World Inflation and Recession. The American Economic Review, 72(4): 738–751.

Dramani, J. B., Frimpong, P. B., 2020. The effect of crude oil price shocks on macroeconomic stability in Ghana. OPEC Energy Review, 43(3): 249–277.

Edelstein, P. Kilian, L., 2007. The Response of Business Fixed Investment to Changes in Energy Prices: A Test of Some Hypotheses about the Transmission of Energy Price Shocks. The B.E. Journal of Macroeconomics, 7(1): 1–41.

Hamilton, J. D., 1983. Macroeconomy since World War II. Journal of Political Economy, 91(2): 228–248.

Hamilton, J. D., 2008. Oil and the Macroeconomy. In: S. N. Durlauf and L. E. Blume (eds.), The New Palgrave Dictionary of Economics, Second Edition, Palgrave Macmillan.

Herrara, A. M., and E. Pesavento, 2009. Oil Price Shocks, Systematic Monetary Policy, and the "Great Moderation". Macroeconomic Dynamics, 13(1): 107–137.

Hooker, M. A., 2002. Are Oil Shocks Inflationary? Asymmetric and Nonlinear Specifications versus Changes in Regime. Journal of Money, Credit and Banking, 34(2): 540–561.

Iwayemi, A., Fowowe, B., 2011. Oil and the macroeconomy: empirical evidence from oil-exporting African countries. OPEC Energy Review, 35(3): 227–269.

Jimenez-Rodriguez, R., Sanchez, M., 2005. Oil price shocks and real GDP growth: empirical evidence for some OECD countries. Applied Economics, 37(2): 201–228.

Kilian, L., 2008. The Economic Effects of Energy Price Shocks. Journal of Economic Literature, 46(4), 871–909.

Kilian, L., 2009. All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market. American Economic Review, 99(3): 1053–1069.

Lipovetsky, S., Conklin, M., 2001. Regression as weighted mean of partial lines: interpretation, properties, and extensions. International Journal of Mathematics Education in Science and Technology, 32(5): 697–706.

Mork, K. A., 1994. Business Cycles and the Oil Market. The Energy Journal, 15(1): 15–38.

Mork, K. A., Olsen O., Mysen, H. T., 1994. Macroeconomic Responses to Oil Price Increases and Decreases in Seven OECD Countries. The Energy Journal, 15(4): 19–35.

Oladosu, G. A., Leiby, P. N., Bowman, D. C., Uria-Martinez, R., Johnson, M. M., 2018. Impacts of oil price shocks on the United States economy: A meta-analysis of the oil price elasticity of GDP for net oil-importing economies. Energy Policy, 115: 523–544.

Omolade, A., Ngalawa, H., Kutu, A., 2019. Crude oil price shocks and macroeconomic performance in Africa's oil-producing countries. Cogent Economic & Finance, 7(1): 1607431.

Pedersen, M., Ricaurte, M. B., 2014. Efectos de shocks al precio del petróleo sobre la economía de Chile y sus socios comerciales. Economía chilena, 17(1): 38–65.

Pinchera, B., García, A. G., 2007. Shocks de petróleo e inflación, el caso de Chile y una muestra de países industrials. Economía chilena, 10(1): 5–36.

Quintero Otero, J. D., 2020. Not all sectors are alike: Differential impacts of oil shocks in oil prices on the sectors of the Colombian economy. Energy Economics, 86: 104691.

Raduzzi, R., Ribba, A., 2020. The macroeconomic outcomes of oil shocks in small Eurozone economies. The World Economy, 43(1): 191–211.

Ramey, V. A, Vine, D. J., 2011. Oil, Automobiles, and the U.S. Economy: How Much Have Things Really Changed? NBER Macroeconomics Annual, 25(1): 333–368.

Ran, J., Voon, J. P., 2012. Does oil price shock affect small open economies? Evidence from Hong Kong, Singapore, South Korea and Taiwan. Applied Economics Letters, 19(16): 1599–1602.

Sekine, A., 2020. Oil price pass-through to consumer prices and the inflationary environment: A STAR approach. Applied Economics Letters, 27(6): 484–488.

Souza, R. S., Mattos, L. B., 2021. Oil price shocks, exchange rate and uncertainty: case of Latin American economies. Applied Economics Letters, 28(7): 1–7.

Data appendix

U.S. Energy Information Administration, Petroleum and other liquids: International: Annual crude and lease condensate exports; https://www.eia.gov/international/data/world/petroleum-and-other-liquids/annual-crude-and-lease-condensate-exports, November 11, 2020.

U.S. Energy Information Administration, Petroleum and other liquids: International: Annual crude and lease condensate imports; https://www.eia.gov/international/data/world/petroleum-and-other-liquids/annual-crude-and-lease-condensate-imports, November 11, 2020.

The World Bank, World Development Indicators: GDP (constant 2010 US$); https://databank.worldbank.org/reports.aspx?source=World-Development-Indicators, October 28, 2020.

The World Bank, World Development Indicators: Exports of Goods and services (constant 2010 US$); https://databank.worldbank.org/reports.aspx?source=World-Development-Indicators, October 28, 2020.

The World Bank, World Development Indicators: Imports of Goods and services (constant 2010 US$); https://databank.worldbank.org/reports.aspx?source=World-Development-Indicators, October 28, 2020.

Chile

OECD, Consumer Price Index: All Items for Chile [CHLCPIALLQINMEI], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/CHLCPIALLQINMEI, June 14, 2020.

OECD, Consumer Price Index: All Items Excluding Food and Energy for Chile [CHLCPICORMINMEI], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/CHLCPICORMINMEI, August 27, 2020.

OECD, International Trade: Exports: Value (goods): Total for Chile [CHLXTEXVA01NCMLQ], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/CHLXTEXVA01NCMLQ, August 26, 2020.

OECD, Immediate Rates: Less than 24 Hours: Call Money/Interbank Rate for Chile [IRSTCI01CLQ156N], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/IRSTCI01CLQ156N, June 14, 2020.

OECD, Unemployment Rate: Aged 15 and Over: All Persons for Chile [LRUNTTTTCLQ156N], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/LRUNTTTTCLQ156N, October 2, 2020.

International Monetary Fund, Global price of WTI Crude [POILWTIUSDQ], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/POILWTIUSDQ, October 3, 2020.

OECD, Total Manufacturing Production for Chile [PRMNTO01CLQ661N], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/PRMNTO01CLQ661N, October 2, 2020.

Bank for International Settlements, Real Broad Effective Exchange Rate for Chile [RBCLBIS], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/RBCLBIS, October 3, 2020.

Banco Central de Chile, National Accounts: GDP at Current Prices; https://si3.bcentral.cl/Siete/EN/Siete/Cuadro/CAP_CCNN/MN_CCNN76/CCNN2013_P0_V2/CCNN2013_P0_V2, June 14, 2020.

OECD, National Currency to US Dollar Spot Exchange Rate for Chile [CCUSSP02CLQ650N], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/CCUSSP02CLQ650N, November 9, 2020.

Colombia

Bank for International Settlements, Real Broad Effective Exchange Rate for Colombia [RBCOBIS], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/RBCOBIS, June 3, 2020.

OECD, Consumer Price Index: All items: Total: Total for Colombia [COLCPALTT01IXOBQ], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/COLCPALTT01IXOBQ, June 3, 2020.

OECD, Consumer Price Index: OECD Groups: All items non-food non-energy: Total for Colombia [COLCPGRLE01IXOBQ], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/COLCPGRLE01IXOBQ, June 3, 2020.

OECD, Production: Manufacturing: Total manufacturing: Total manufacturing for Colombia [COLPRMNTO01IXOBSAM], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/COLPRMNTO01IXOBSAM, June 3, 2020.

OECD, Currency Conversions: US$ exchange rate: Average of daily rates: National currency: USD for Colombia [COLCCUSMA02STQ], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/COLCCUSMA02STQ, November 9, 2020.

Banco de la República, Exportaciones: Exportaciones totales (FOB); https://www.banrep.gov.co/es/estadisticas/exportaciones, June 6, 2020.

Departamento Administrativo Nacional de Estadística, Producto Interno Bruto – PIB – nacional trimestral: Año 2020: trimestre II: PIB a precios corrientes; https://www.dane.gov.co/index.php/estadisticas-por-tema/cuentas-nacionales/cuentas-nacionales-trimestrales/historicos-producto-interno-bruto-pib, August 29, 2020.

Banco de la República, Tasa interbancaria (TIB): Serie histórica; https://www.banrep.gov.co/es/estadisticas/tasa-interbancaria-tib, October 8, 2020.

Banco de la República, Tasas de ocupación y desempleo: Total nacional; https://www.banrep.gov.co/es/estadisticas/tasas-ocupacion-y-desempleo, October 8, 2020.

Brazil

OECD, Gross Domestic Product by Expenditure in Current Prices: Total Gross Domestic Product for Brazil [NAEXCP01BRQ189N], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/NAEXCP01BRQ189N, January 21, 2021.

OECD, National Currency to US Dollar Spot Exchange Rate for Brazil [CCUSSP02BRQ650N], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/CCUSSP02BRQ650N, January 1, 2021.

OECD, Total Manufacturing Production for Brazil [PRMNTO01BRQ661N], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/PRMNTO01BRQ661N, January 1, 2021.

OECD, Exports: Value Goods for Brazil [XTEXVA01BRQ667N], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/XTEXVA01BRQ667N, January 1, 2021.

OECD, Consumer Price Index: All Items for Brazil [BRACPIALLMINMEI], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/BRACPIALLMINMEI, January 1, 2021.

OECD, Immediate Rates: Less than 24 Hours: Call Money/Interbank Rate for Brazil [IRSTCI01BRQ156N], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/IRSTCI01BRQ156N, January 1, 2021.

OECD, Unemployment Rate: Aged 15 and Over: All Persons for Brazil [LRUNTTTTBRQ156N], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/LRUNTTTTBRQ156N, January 1, 2021.

Bank for International Settlements, Real Broad Effective Exchange Rate for Brazil [RBBRBIS], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/RBBRBIS, January 1, 2021.