Does central bank credibility help mitigate the effect of oil price shocks on price diffusion?

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Resumo

O presente artigo investiga o efeito do *pass-through* do preço internacional do petróleo e da credibilidade do branco central sobre a difusão de aumentos de preço ao consumidor. Os dados utilizados permitem considerar o *pass-through* do preço internacional do petróleo e calcular índices de difusão de preços e indicadores de credibilidade do banco central para dezenove países durante o período de 2002 a 2019. Os resultados encontrados indicam que tanto o *pass-through* do preço internacional do petróleo quanto a credibilidade do banco central são relevantes para explicar a difusão de preços. Encontra-se evidência de que os efeitos dinâmicos do pass-through do preço internacional do petróleo e da credibilidade do banco central sobre a difusão de preços são duradouros. Ademais, os resultados indicam uma assimetria no efeito de aumentos e reduções no preço do petróleo sobre a difusão de preços.

Palavras-chave: *pass-through* do preço do petróleo, credibilidade do banco central, difusão de preços.

Abstract

This paper investigates the effects of international oil price pass-through and the central bank credibility on the diffusion of price increases among consumer prices. We use data that permit us to consider the international oil price pass-through and calculate the price diffusion index and central bank credibility indexes for nineteen countries from 2002 to 2019. The findings show that both the international oil price pass-through and the central bank credibility are relevant in explaining the price diffusion. The dynamic effects of oil price pass-through and credibility on price diffusion are long-lasting. Moreover, our results point out an asymmetry in the effect of increases and decreases in the oil price.

Keywords: oil price pass-through, central bank credibility, price diffusion.

Classificação JEL: E31, E52, Q43.

Área 4 - Macroeconomia, Economia Monetária e Finanças

1. Introduction

This article investigates the effects of international oil price pass-through and the central bank credibility on the diffusion of price increases among consumer prices based on panel data analysis.[1] Specifically, we analyze how the price diffusion index behaves in the face of changes in the international oil price and credibility indexes that consider the deviation of medium-term inflation expectations related to the inflation target in nineteen countries. The price diffusion index shows the proportion of items with positive variation in the consumer price index.[2] Hence, it is a "thermometer" of how widespread price increases are. Besides, it is widely accepted that there is an oil price pass-through into inflation and that credibility helps control inflation. Therefore, it is essential to analyze the direct impact of the oil price pass-through and the central bank credibility on the price diffusion.

The literature dealing with the oil price pass-through effect focuses on investigating its direct impact on inflation. While inflation is central to monetary policy decisions, one fundamental issue has been overlooked: not all price changes are of the same nature. An oil price shock should not be inflationary per se, as it only represents a change in relative prices (Humpage and Pelz, 2003). However, as many sectors of the economy are intensive in oil products, oil price shocks can trigger a shift in relative prices in several sectors. As many sectors are affected by the shock, it is natural that a variation in the price indices used to measure inflation is observed. This change, however, differs from a generalized increase in the economy's prices, that is, from an inflationary shock. Therefore, it is necessary to use another indicator to assess whether an oil price shock is inflationary. An alternative that allows us to assess this issue accurately is to use a price diffusion index, which measures precisely how widespread the price increases within a price index are.

Assessing whether oil price shocks affect prices in a generalized way or are restricted to a few sectors is essential, for example, to the central bank to take more proactive measures to combat an inflationary process. The traditional mechanism to combat it would be an increase in the monetary policy interest rate. However, the development of the inflation targeting regime is a structure that seeks to contain inflationary pressure through the expectations channel. The expectations channel is vital in this context because relative price shocks can considerably impact inflation expectations. Consumers can use the variation in prices of goods they encounter weekly, such as gasoline and food, as a sign that the general price level is rising, when, in reality, large variations in these products represent only a change in prices relatives (Humpage, 2008). The central bank has no control over supply shocks that impact relative prices by increasing production costs. However, the monetary authority can reduce this irrational behavior on the part of agents, contaminating inflation expectations, increasing public confidence in its commitment to price stability. In short, although they are "independent channels", it is possible that the central bank credibility represents a mechanism capable of preventing the spread of price increases in the economy and, therefore, curbing the pressure resulting from an increase in the international oil price.

Analyzing the impact of the oil price on the price diffusion index makes it possible to identify contagion in other prices in the economy and whether the central bank credibility would avoid this contagion effect. While an increase in the international oil price can lead to an increase in the price diffusion due to an increase in the cost of production, the central bank credibility works as a shock absorber because the economic agents believe that the announced inflation target will be reached.

Our analysis uses information data to calculate the price diffusion index of nineteen countries from 2002 to 2019. The period under consideration allows us to analyze whether the international oil price has played a more relevant role in the inflation process since the end of the 2000s, as pointed out by recent studies (see Renou-Maissant, 2019). Furthermore, as suggested in Fukač (2011) and Adekoya and Adebiyi (2020), it permits us to assess whether the global financial crisis of 2007-2008

[1] Throughout this paper, the "central bank credibility" refers to the central bank's ability to maintain medium-term inflation expectations within previously announced tolerance intervals for inflation fluctuation.
[2] Henceforth, we will refer to the diffusion of increases among consumer prices as price diffusion.

changed the relationship between oil prices and inflation. The data set covers the total of countries that use inflation targets and provide medium-term inflation expectations from their central banks. We consider three credibility measures that have the gap between the targets and inflation expectations in essence (see Blinder, 2000). Moreover, we regress the price diffusion index directly on the variation in the international oil price and the credibility measures. In addition, we investigate whether there is an asymmetry of positive and negative oil shocks on price diffusion. Finally, we analyzed the dynamic relationships between the variables of interest. The results show that the international oil price pass-through and the central bank credibility are relevant to the price diffusion.

To consider the possible changes due to the global financial crisis, we re-estimated the models based on a sub-sample comprising the period 2009-2019. Although there was a sharp drop in oil prices in mid-2008, we did not detect a significant change in the results compared to those found for the total sample. Moreover, oil shocks may have different impacts on the different countries in the sample. To consider this possibility, we re-estimated the models taking into account the variation in the international oil price weighted by the energy consumption/GDP ratio of each country. The results confirm that both oil price pass-through and credibility are significant in explaining price diffusion.

Oil price shocks have an immediate impact on inflation due to the direct effect on consumers' prices for energy products. Furthermore, there are two transmission channels through which the indirect effect of the oil price pass-through on inflation can be significant: the cost channel and the expectations channel.[3] The cost channel is related to the fact that an increase in the oil price causes an increase in production and transport cost that results in an inflationary pressure (Chen, Zhu, and Li, 2020; Adekoya and Adebiyi, 2020; and Nusair, 2019). The expectations channel concerns the situation that, when there is no confidence that the central bank is capable of maintaining low and stable inflation, an increase in the oil price may generate revisions in inflation expectations that may lead to higher inflation (Albulescu, Oros, and Tiwari, 2017, and Fukač, 2011).

The relationship between the effects of an increase in the international oil price on inflation and monetary policy is especially associated with the channel of expectations. Central banks' success in keeping inflation expectations stable over the medium term is essential to control inflation (Fukač, 2011). According to Bernanke et al. (1997), monetary policy may cushion the shock of an increase in oil price, but the effect of a contractionary policy may lead to an economic recession. However, the better conduct of monetary policy due, for example, to the use of inflation targets by central banks has increased credibility (López-Villavicencio and Pourroy, 2019). The central bank credibility is crucial because it influences expectations by affecting interest and exchange rates, reducing the cost of fighting inflation in terms of product loss and employment (de Mendonça and de Guimarães e Souza, 2012). In brief, an increase in credibility represents a better anchoring of inflation expectations creating a low inflationary environment (Nasir, Huynh, Yarovaya, 2020; and Sek, 2017).

Some studies point to the fact that the effect of oil shocks on inflation has diminished over the last two decades of the 20th century (see, for example, Hooker, 2002; De Gregorio, Landerretche, and Neilson, 2007; Chen, 2009; and Clark and Terry, 2010). An argument pointed out by the literature for the decline in oil price pass-through is the change in a monetary policy stance that has become more incisive in the fight against inflation (Taylor, 2000). Nevertheless, studies that consider data from the 21st century indicate that there has been a recovery in the importance of the role of oil prices in the inflation process in several countries (Renou-Maissant, 2019). The trend of increasing oil price pass-through to inflation in the 2000s is detected, for example, in countries such as the USA (Fukač, 2011), Australia (Paradiso and Rao, 2012), the United Kingdom (Millard and Shakir, 2013), and the Eurozone (Oinonen and Paloviita, 2014). Furthermore, recent studies show that the aggregate price level's future value can be predicted by the oil price (Salisu, Ademuyiwa, and Isah, 2018).

In sum, the resumption of the oil price pass-through makes it necessary to find mechanisms

[3] Some authors point to the result of a demand for higher wages to compensate for the increase in oil prices as a third channel (see, for example, Conflitti and Luciani, 2019). However, this channel is a consequence of inflation expectations revisions (see, Fukač, 2011).

that lead to greater monetary policy effectiveness to keep inflation under control. In particular, an increase in diffusion is a sign that rising prices are spreading across the economy, and inflation is becoming persistent, which justifies a monetary policy response. Our article contributes to this branch of literature and stands out concerning the existing one in several aspects. Firstly, as far as we know, our article is the first to analyze the effect that variations in the international oil price have on price diffusion. Secondly, we are also the first to present empirical evidence of the effect of the central bank credibility as a tool capable of containing the spread of price increases. Thirdly, to assess the "contagion effect" that an increase in the international oil price has on economies, we built price diffusion indices for 19 countries on a quarterly basis. Finally, based on medium-term inflation expectations and inflation targets provided by central banks in 19 countries, we calculate three central bank credibility measures for 2002-2019.[4]

The remainder of this paper is structured as follows. Section 2 shows the procedure for generating the variables of interest in the study and a preliminary analysis of the relationship among them. Section 3 presents the methodology used to assess the international oil price and the central bank credibility effects on price diffusion. Section 4 shows and analyzes the result of the models. Section 5 concludes.

2. On the measurement of price diffusion, international oil prices, and central bank credibility

The price diffusion allows identifying if this impact is spread among all the consumer price index categories or limited to the oil-intensive production categories. A simple way of measuring how widespread consumer price increases are in the economy of a country i, in period t, is through a price diffusion index ($PDI_{i,t}$) that measures the proportion of categories of the index that showed price increases in relation to the total of categories (K). Therefore, if, in period t, category k showed an increase in its price ($\pi_{i,t}^{k} > 0$), it is added to the number of categories with price increases. Hence, the index is calculated as the proportion of categories with price increases to the total number of categories:

(1) $$PDI_{i,t} = \frac{1}{K}\sum_{k=1}^{K} \mathbb{I}\left(\pi_{i,t}^{k} > 0\right); \quad \mathbb{I}\left(\pi_{i,t}^{k} > 0\right) = \begin{cases} 1, & if \quad \pi_{i,t}^{k} > 0 \\ 0, & if \quad \pi_{i,t}^{k} \leq 0 \end{cases}.$$

The ideal to build the diffusion index is to work with product categories as detailed as possible, which, in general, are consumer price index (CPI) items. However, this type of information is not available in several countries. Hence, we use information similar to the expenditure classes defined in the Classification of Individual Consumption According to Purpose (COICOP 18).[5] The frequency of data for calculating the diffusion index is quarterly due to the availability of information and the fact that price transfers can occur during consecutive months or can be reversed in subsequent months.

To analyze the international oil price pass-through on the price diffusion, we consider the variation in the international oil prices (ΔOIL) resulting from the difference of the international oil price (log) between the quarters t and $t-1$.[6] The international oil price in this study is approximated by the average, available in the International Financial Statistics (IFS) of the International Monetary Fund (IMF), of three spot prices: Dated Brent, West Texas Intermediate, and Dubai Fateh.[7]

To consider the effect of the central bank credibility on the price diffusion to the consumer, we

[4] Our sample considers 19 countries that adopt inflation targeting and that their central banks disclose, through their website, medium-term inflation expectations from the central banks' expectations surveys with economic agents for the period from the first quarter of 2002 to the last quarter of 2019.

[5] Categories used for each country are available upon request to the authors.
[6] The price in each quarter is a result of the quarterly average of daily prices.
[7] This measure is frequently used in the literature, as, for example, in Benhmad (2012), Nazlioglu and Soytas (2012), Lippi and Nobili (2012), Dube and Vargas (2013), Juvenal and Petrella (2015), and Baghestani (2016).

use time-varying credibility indices suitable for analyzing countries with inflation targets. Precisely, we stem from the original Cukierman and Meltzer's (1986) credibility definition. In other words, in countries with inflation targets, the previously announced inflation target represents a "policymaker's plan" while inflation expectations represent "public beliefs" concerning that plan.

An important issue that arises when using the above definition is the horizon for which inflation expectations are formed. The European Central Bank, for example, only communicates that the main objective of its monetary policy is to maintain price stability over the medium term. The Central Bank of New Zealand reports that after defining conditional projections for the economy over the next two to three years, a committee meets to make monetary policy decisions. The Central Bank of Japan, in turn, has a significant perspective for the conduct of monetary policy to examine whether the expected paths for economic activity and prices over the next two years or so follow a trajectory of sustained growth with price stability.

The medium-term time horizon is most used to manage a central bank's monetary policy, and it lies between two and three years ahead. Therefore, a measure of central bank credibility must consider expectations for the same horizons mentioned. This interpretation is consistent with the fact that two-year horizons for inflation expectations are prevalent in central bank surveys for information collection. Regarding the sample we are using, the central banks of the nineteen countries under consideration have expectations of inflation for the horizons of two or three years ahead.[8]

To measure the central bank credibility, we use indexes that capture the essence of credibility in an economy with an inflation target: the difference between inflation expectations and the inflation target considering a medium-term horizon (two or three years ahead). Specifically, we consider three credibility indexes that vary from 0 (without credibility) to 1 (maximum credibility) but present different characteristics regarding the treatment of the deviation from inflation expectations to the target. The first index that we consider is based on de Mendonça (2007). From this perspective, credibility is maximum (*CRED*1=1) when inflation expectations are equal to the announced target, and it is equal to zero (*CRED*1=0) when inflation expectations surpass one of the limits established by the tolerance interval [INF^{lower}, INF^{upper}]. This index shows a linear loss of credibility as inflation expectations ($E(INF)$) move away from the inflation target (INF^{target}) until it reaches one of the limits of the tolerance interval, that is, *CRED*1=]0,1[. Thus, considering the two-year horizon ahead (8 quarters = t+8), we have:

(2) $CRED1_{i,t} =$

$$\begin{cases} 1 & \text{if} \quad E_t(INF_{i,t+8}) = INF_{i,t+8}^{target} \\ 1 - \frac{1}{INF_{i,t+8}^{upper} - INF_{i,t+8}^{target}}\left[E_t(INF_{i,t+8}) - INF_{i,t+8}^{target}\right] =]0,1[& \text{if} \quad INF_{i,t+8}^{target} < E_t(INF_{i,t+8}) < INF_{i,t+8}^{upper} \\ 1 - \frac{1}{INF_{i,t+8}^{target} - INF_{i,t+8}^{lower}}\left[E_t(INF_{i,t+8}) - INF_{i,t+8}^{target}\right] =]0,1[& \text{if} \quad INF_{i,t+8}^{lower} < E_t(INF_{i,t+8}) < INF_{i,t+8}^{target} \\ 0 & \text{if} \quad E_t(INF_{i,t+8}) \geq INF_{i,t+8}^{upper} \text{ or } E_t(INF_{i,t+8}) \leq INF_{i,t+8}^{lower} \end{cases}.$$

The second central bank credibility index (*CRED*2) in our analysis has as its main difference from the previous one the fact that it considers a loss of credibility that is not linear when inflation expectations diverge from the announced target. Intuitively, it is reasonable to assume that the loss of credibility when there are slight deviations from inflation expectations to the target will be smaller than when the deviations are large. Based on de Mendonça and Almeida (2019), we calculated the credibility index *CRED*2 for each country in the sample over time as:

[8] Table A.1 (appendix) shows the data sources regarding the inflation expectations used for each of the nineteen countries in the sample.

(3) $CRED2_{i,t} =$

$$\begin{cases} 1 & \text{if} \quad E_t(INF_{i,t+8}) = INF^{target}_{i,t+8} \\ \frac{\sqrt{\left[INF^{target}_{i,t+8} - INF^{upper}_{i,t+8}\right]^2 - \left[E_t(INF_{i,t+8}) - INF^{target}_{t+8}\right]^2}}{INF^{upper}_{i,t+8} - INF^{target}_{t+8}} =]0,1[& \text{if} \quad INF^{target}_{i,t+8} < E_t(INF_{i,t+8}) < INF^{upper}_{i,t+8} \\ \frac{\sqrt{\left[INF^{target}_{i,t+8} - INF^{lower}_{i,t+8}\right]^2 - \left[E_t(INF_{i,t+8}) - INF^{target}_{t+8}\right]^2}}{INF^{lower}_{i,t+8} - INF^{target}_{t+8}} =]0,1[& \text{if} \quad INF^{lower}_{i,t+8} < E_t(INF_{i,t+8}) < INF^{target}_{i,t+8} \\ 0 & \text{if} \quad E_t(INF_{i,t+8}) \geq INF^{upper}_{i,t+8} \text{ or } E_t(INF_{i,t+8}) \leq INF^{lower}_{i,t+8} \end{cases}.$$

Finally, we consider a credibility index (*CRED*3) that takes into account the asymmetric effect of positive and negative deviations between inflation expectations and the target. This index uses a linear exponential function (LINEX) inspired by Levieuge, Lucotte, and Ringuedé (2018), and captures the idea that, in practice, inflation expectations below the target have less impact on the loss of credibility in comparison to the case of expectations above the target. The index is defined as:

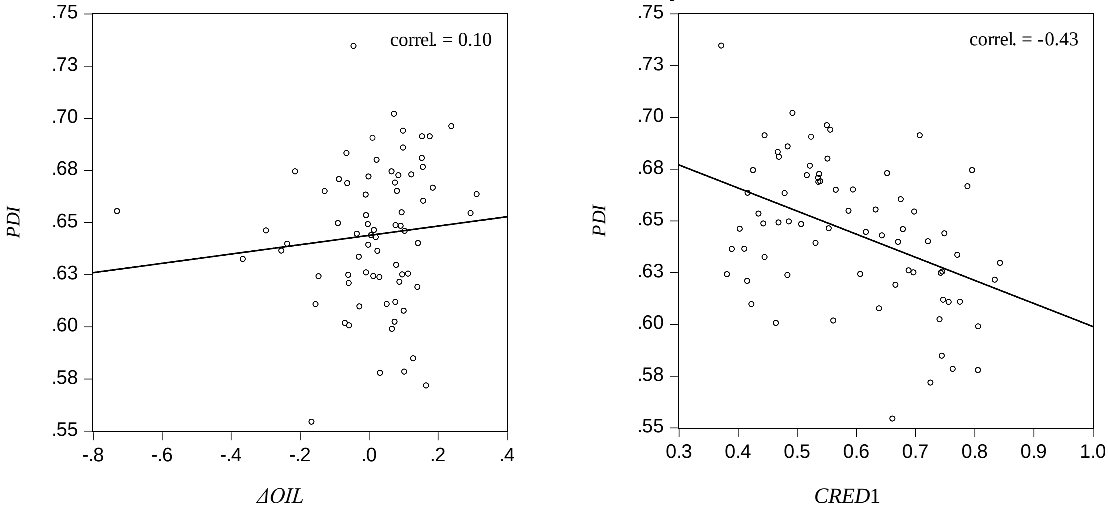
(4) $CRED3_{i,t} =$

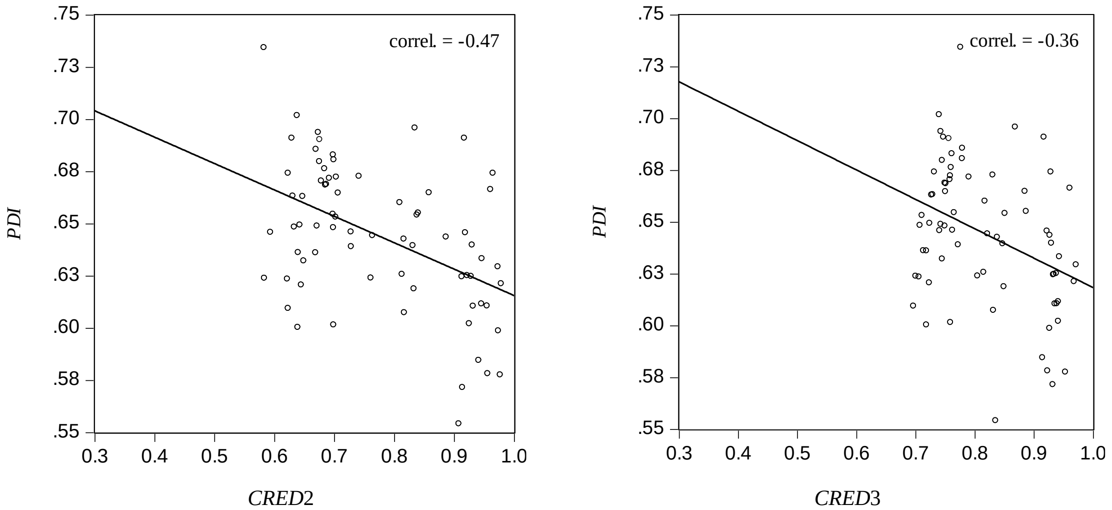
$$\begin{cases} 1 & \text{if} \quad E_t(INF_{i,t+8}) = INF^{target}_{i,t+8} \\ \frac{1}{\left\{\left[e^{\left[E_t(INF_{i,t+8}) - INF^{target}_{t+8}\right]}\right] - \left[E_t(INF_{i,t+8}) - INF^{target}_{t+8}\right]\right\}} = [0,1[& \text{if} \quad E_t(INF_{i,t+8}) \neq INF^{target}_{i,t+8} \end{cases}.$$

To observe, in a preliminary way, whether there is a relationship between the variation in the international oil price and the average central bank credibility with the average price diffusion, we made use of scatterplots with the variables of interest. Figure 1 shows that the correlation between the variation in the international oil price and the price diffusion is positive (0.10), while the correlations between the variation in the oil price and the measures of credibility are negative (*CRED*1=-0.43, *CRED*2=-0.47, and *CRED*3=-0.36).

Figure 1

Correlation between price diffusion index and variation in the international oil price and central bank credibility indexes





Notes: ΔOIL is the variation in the international oil prices. *PDI* and *CRED* are the quarterly average of price diffusion index (*PDI*) and central bank credibility indexes (*CRED*1, *CRED*2, and *CRED*3 - see equations 2 to 4) for all 19 countries in the sample from 2002 to 2019.

3. Empirical strategy

It is common to use the augmented Phillips Curve to analyze the effect of oil price pass-through on inflation (see, for example, Chen, 2009; Çatik and Önder, 2011; Renou-Maissant, 2019; and Adekoya and Adebiyi, 2020). Therefore, we use a similar specification to estimate the effect of oil price pass-through and central bank credibility on the price diffusion index:

(5) $PDI_{i,t} = \beta_1 PDI_{i,t-1} + \beta_2(y_{i,t} - y_{i,t-4}) + \beta_3 \Delta OIL_t + \beta_4 CRED_{i,t} + \varepsilon_{i,t}$,[9]

where: i = 1, 2, ..., 19 represents the countries; t=1, 2, ..., 72 are the time periods (quarterly frequency) from 2002 to 2019; $PDI_{i,t}$ is the price diffusion index for country i in quarter t calculated according to equation 1; $y_{i,t} - y_{i,t-4}$ is the growth of the GDP accumulated in four quarters;[10] ΔOIL is the change in the international oil price (log) in a quarter; *CRED* corresponds to the following credibility indexes: *CRED*1, *CRED*2, and *CRED*3 (see equations 2, 3, and 4); and ε is the stochastic error term.

In equation (5), the coefficient β_3 measures the price diffusion index's effect due to a shock on the international oil price. Considering how liked the oil production sector is to other sectors in the economy, we expect $\beta_3>0$. On the other hand, considering that a credible central bank is committed to a low inflation policy, we expect a $\beta_4<0$.

We present empirical evidence from two approaches: Robust Least Squares (RLS) and Systemic Generalized Moments Method (Sys-GMM). Because heteroskedasticity is often in cross-country data, we use RLS to lead with this issue (see Yohai, 1987).[11] Another problem that cannot be overlooked in the models is the possibility of reversed causality; for example, price diffusion can affect the central bank credibility. Moreover, the use of parsimonious models can incur omitted variables bias. Hence, to deal with the mentioned problems, we use Sys-GMM. The Sys-GMM extends the Differenced GMM estimator by hypothesizing that the first difference in instrumental variables is not correlated with fixed effects, allowing more instruments and improving efficiency (Roodman, 2009). Specifically, as proposed by Arellano and Bover (1995) and Blundell and Bond (1998), the Sys-GMM method is composed of a system that includes equations in first difference (with lags in level as instruments) and in level (with lags in first difference as instruments). As usual, we perform tests to safeguard our regression results: overidentification restrictions test (test J) proposed by Arellano

[9] Table A.2 (appendix) shows the descriptive statistics for all variables used in the models.

[10] We calculate the growth in four quarters based on the real GDP growth rates from the IMF's International Financial Statistics (IFS).

[11] We use the "MM" estimation that considers outliers' presence both in the dependent and independent variables.

(2003), Arellano and Bond's (1991) first and second-order serial correlation tests (AR1 and AR2). Finally, to prevent the problems related to using an excessive quantity of instruments (see Roodman, 2009), we consider a number of instruments/number of cross-sections ratio less than 1 (de Mendonça and Barcelos, 2015).[12]

The 2008-2009 global recession marked the period under analysis. Specifically, the Brent crude oil price plummeted from around US$ 150 per barrel in mid-2008 to around US$ 40 per barrel at the turn of 2009 (European Central Bank, 2012). Hence, the period after this drop of more than 70% in the oil price may have changed the effect of the oil price pass-through on the price diffusion index. Moreover, the three credibility indexes under consideration show a decrease in 2008, and the period after that year indicates that there was no recovery to the levels observed in the previous period. In short, the central bank credibility effect on price diffusion can have diminished. Therefore, we re-estimate the previous models considering the subsample 2009-2019.

An important question is regarding the asymmetric effect of variations in the oil price on price diffusion. There is evidence that positive shocks in the oil price have a greater effect than negative shocks (Choi et al., 2018). According to López-Villavicencio and Pourroy (2019), on the one hand, assuming a non-competitive market structure, when there is an increase in the international oil price, domestic oil companies also increase their prices to maintain their profit margins. Thus, due to the cost channel, the result is an increase in the general price level. On the other hand, when there is a reduction in the international oil price, companies are not quick to reduce prices due to the drop in cost, as this way they get an additional profit.

To investigate the asymmetric effect on the price diffusion index when there are positive and negative variations in the oil price, we use the following specification:

(6) $$PDI_{i,t} = \alpha_1 PDI_{i,t-1} + \alpha_2(y_{i,t} - y_{i,t-4}) + \alpha_3 \Delta OIL_t^+ + \alpha_4 \Delta OIL_t^- + \alpha_5 CRED_{i,t-1} + \alpha_{0i} + \zeta_{i,t},$$

where: ΔOIL^+ is equal to the positive change in the international oil price (log), and it assumes zero when $\Delta OIL_t<0$. We use the absolute value of the negative change in the international oil price to make the result intuitive. Therefore, ΔOIL^- corresponds to the negative change in the international oil price ($|\Delta OIL_t<0|$) in log, and it assumes zero when $\Delta OIL_t>0$. In short, to analyze the asymmetric effect, we consider the positive and negative variations in the oil price as:

$$\Delta OIL_t^+ = \begin{cases} \Delta OIL_t, & \text{if } \Delta OIL_t > 0 \\ 0, & \text{otherwise} \end{cases} ; \text{and } \Delta OIL_t^- = \begin{cases} |\Delta OIL_t|, & \text{if } \Delta OIL_t < 0 \\ 0, & \text{otherwise} \end{cases} .$$

Indeed, the variation in the international oil price does not have a homogeneous effect for all countries. Thus, we carried out a robustness exercise that consists of replacing the variable ΔOIL_t with another variable that weighs the oil price impact by the ratio between total energy consumption and the GDP ($W\Delta OIL$) to analyze the oil price pass-through effect on the price diffusion index.[13] Consequently, we rewrote equation (5) as:

(7) $$PDI_{i,t} = \delta_1 PDI_{i,t-1} + \delta_2(y_{i,t} - y_{i,t-4}) + \delta_3 W\Delta OIL_{i,t} + \delta_4 CRED_{i,t} + \delta_{0i} + \nu_{i,t},$$

where: $W\Delta OIL_{i,t}$ is the result of ΔOIL_t multiplied by each country's energy consumption/GDP.

Finally, based on the variables in equation (5), we perform a structural autoregressive vector model (SVAR) on the stacked data. An advantage in using VAR models is that, despite the challenges,

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[12] Besides the lagged regressors, we use as instrumental variables in the models: variation in the monetary policy interest rate (source: International Financial Statistics (IFS) and, when unavailable on this source, we take from central bank websites); inflation rate (measured by CPI gathered from the statistical institutes of the sample countries); exchange rate (in units of national currency per US dollar - IFS source); and net oil imports (calculated from the difference between imports and exports of crude oil available from the United States Department of Energy - EIA). The list of instruments for each model is available upon request to the authors.

[13] The ratio is between the energy consumption in quadrillions of British thermal units (BTUs) and GDP, using 2015 purchasing power parity in billions of US dollars, extracted from the United States Department of Energy (EIA) database, and interpolated for the generation of a quarterly series.

r, Bloom, and Davies, 2016). ects of economic shocks without AR model estimated in this study

T,

a vector of endogenous variables is the vector of structural shocks; vector of constants 1×4.[14]

[redacted]

credibility index, there is evidence that the central bank's a [redacted] towards the inflation target represents a helpful tool to redu [redacted]

Table 1

ffect of oil price pass-through and central bank cre [redacted]

Regressors	Robust Least Squares (RLS)			[redacted]		
	Model 1 (*CRED*1)	Model 2 (*CRED*2)	Model 3 (*CRED*3)	Model 1 (*CRED*1)	Model 2 (*CRED*2)	Model 3 (*CRED*3)

The coefficients on *ΔOIL* and *CRED* are similar to those observed for the total sample. Therefore, there is no indication that the great recession of 2008-2009 has changed the relevance of the oil price pass-through and the central bank credibility for the price diffusion. In brief, the recent period confirms the idea that an increase in the international oil price is relevant to explain an increase in price diffusion and that the central bank credibility contributes to a reduction.

Table 2

Effect of oil price pass-through and central bank credibility on price diffusion (2009-2019)

	Robust Least Squares (RLS)			System Gen. Met. of Moments (Sys-GMM)		
Regressors	Model 1 (*CRED*1)	Model 2 (*CRED*2)	Model 3 (*CRED*3)	Model 1 (*CRED*1)	Model 2 (*CRED*2)	Model 3 (*CRED*3)
$PDI_{i,t-1}$	0.776***	0.769***	0.710***	0.082	0.149	-0.033
	(0.025)	(0.026)	(0.028)	(0.130)	(0.141)	(0.180)
$y_{i,t} - y_{i,t-4}$	0.0004	0.0003	-0.0001	0.005	0.003	0.003
	(0.001)	(0.001)	(0.001)	(0.002)	(0.008)	(0.006)
$\Delta OIL_{i,t}$	0.084***	0.082***	0.086***	0.596***	0.444***	0.553***
	(0.023)	(0.023)	(0.022)	(0.137)	(0.076)	(0.148)
$CRED_{i,t}$	-0.020***	-0.026***	-0.067***	-0.145***	-0.111***	-0.269***
	(0.009)	(0.009)	(0.012)	(0.020)	(0.040)	(0.072)
Adj. R^2	0.480	0.481	0.492			
N. Observations	611	610	610	404	404	404
N. inst./N. cross sec.				0.63	0.50	0.50
J statistic (*p-value*)				6.53 (0.37)	9.66 (0.21)	6.44 (0.17)
AR(1) (*p-value*)				-0.43 (0.00)	-0.46 (0.00)	-0.47 (0.00)
AR(2) (*p-value*)				0.08 (0.11)	0.08 (0.11)	0.08 (0.12)

Notes: Marginal significance levels: (***) denotes 0.01, (**) denotes 0.05, and (*) denotes 0.1. Robust standard errors between parentheses (Huber – RLS, and White – Sys-GMM). RLS - constant is omitted for convenience. Sys-GMM - two-step estimation of Arellano and Bover (1995). The sample is an unbalanced panel quarterly data of 19 countries from 2002q1 to 2019q4.

Table 3 shows the result of the regressions based on equation (6). The analysis of the asymmetric effect of changes in the international oil price for the price diffusion index shows an interesting result. Although the coefficients associated with reductions and increases in the international oil price show the expected signs, we only observed statistical significance for both cases in the Sys-GMM models. Besides, the results indicate that the magnitude of the coefficients associated with increases in the international oil price is much greater than that of reductions in the oil price. A possible explanation for this observation is that while increases in the international oil price cause an increase in the production cost passed on to the final consumer to maintain the mark-up, reductions in the international oil price have a lower pass-through due to rigidity caused by market imperfections. Concerning credibility, the coefficients are negative and significant in all models, which confirms this variable's importance in reducing the price diffusion index.

Table 3

Effect of asymmetric oil price pass-through and central bank credibility on price diffusion

Regressors	Robust Least Squares (RLS) Model 1 (*CRED*1)	Model 2 (*CRED*2)	Model 3 (*CRED*3)	System Gen. Met. of Moments (Sys-GMM) Model 1 (*CRED*1)	Model 2 (*CRED*2)	Model 3 (*CRED*3)
$PDI_{i,t-1}$	0.763***	0.755***	0.696***	0.307***	0.322***	0.229**
	(0.023)	(0.024)	(0.026)	(0.077)	(0.091)	(0.111)
$y_{i,t} - y_{i,t-4}$	0.0006	0.0006	0.0002	0.002	0.001	0.002
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
ΔOIL_t^+	0.126***	0.125***	0.137***	1.194***	1.268***	1.035***
	(0.042)	(0.043)	(0.042)	(0.284)	(0.340)	(0.186)
ΔOIL_t^-	-0.036	-0.035	-0.035	-0.442***	-0.460***	-0.363***
	(0.031)	(0.030)	(0.030)	(0.155)	(0.156)	(0.115)
$CRED_{i,t}$	-0.023***	-0.030***	-0.073***	-0.142***	-0.142***	-0.249***
	(0.008)	(0.008)	(0.011)	(0.024)	(0.044)	(0.054)
Adj. R^2	0.474	0.476	0.488			
N. Observations	751	750	750	511	511	506
N. inst./N. cross sec.				0.69	0.69	0.75
J statistic (*p-value*)				10.44 (0.11)	10.02 (0.12)	11.25 (0.13)
AR(1) (*p-value*)				-0.47 (0.00)	-0.47 (0.00)	-0.48 (0.00)
AR(2) (*p-value*)				0.006 (0.89)	0.002 (0.96)	0.02 (0.71)

Notes: Marginal significance levels: (***) denotes 0.01, (**) denotes 0.05, and (*) denotes 0.1. Robust standard errors between parentheses (Huber – RLS, and White – Sys-GMM). RLS - constant is omitted for convenience. Sys-GMM - two-step estimation of Arellano and Bover (1995). The sample is an unbalanced panel quarterly data of 19 countries from 2002q1 to 2019q4.

Because Sys-GMM regressions are robust to the omitted variable bias and simultaneity, they are our benchmark for the analysis. We observed the effect of a shock of 1 standard deviation from the value relative to the average of ΔOIL, ΔOIL^+, ΔOIL^-, *CRED*1, *CRED*2, and *CRED*3, on *PDI* (see table 4). Considering the period 2002-2019, the effect of a shock of 1 standard deviation on the average variation in the international oil price leads to an increase of approximately 13.09% (average of ΔOIL in models 1, 2, and 3). When we consider the sub-sample 2009-2019, the effect decreases to 11.17%, a decrease of almost 2 pp compared to the total period. This observation is in line with studies that point out that although the effect of the oil price pass-through into inflation has been significant, it has decreased over time. Regarding the shock of 1 standard deviation on the central bank credibility indexes average, the effect of reduction in the price diffusion index is approximately 6.99% for 2002-2019 and 9.18% for 2009-2019. This result, which indicates greater credibility effectiveness for the reduction of the price diffusion index in the recent period, is consistent with the view that central banks have been concerned with improving the monetary policy expectations channel through, for example, increasing the transparency (see Dincer and Eichengreen, 2014). Analysis of the asymmetric effect of increases and decreases in the international oil price shows that the shock of 1 standard deviation on the average of ΔOIL^+ e ΔOIL^- leads to an increase of 13% and a decrease of 7% on the price diffusion, respectively.

Table 4

Effect of oil price pass-through shocks and central bank credibility (1 standard deviation) on the price diffusion index

Models:	Variables:	2002-2009	2009-2019	Variables:	Asymmetric
1	*CRED* 1	-6.85%	-8.46%	*CRED* 1	-8.10%
	ΔOIL	14.13%	12.53%	ΔOIL^+	13.50%
				ΔOIL^-	-7.59%
2	*CRED* 2	-5.25%	-6.60%	*CRED* 2	-8.03%
	ΔOIL	12.41%	9.34%	ΔOIL^+	14.34%
				ΔOIL^-	-7.90%
3	*CRED* 3	-8.87%	-12.49%	*CRED* 3	-11.35%
	ΔOIL	12.73%	11.63%	ΔOIL^+	11.71%
				ΔOIL^-	-6.24%
Average	*CRED*	-6.99%	-9.18%	*CRED*	-9.16%
	ΔOIL	13.09%	11.17%	ΔOIL^+	13.18%
				ΔOIL^-	-7.24%

Notes: We use the mean values of the variables and the coefficients in Sys-GMM models (see tables 1, 2, and 3) for calculating the effects. CRED is the average of the credibility indexes.

Table 5 presents the result of the robustness analysis based on equation 3. In general, the oil price weighted by each country's energy consumption did not change the main result. Regardless of the method and model under consideration, the coefficients associated with the variable that captures the oil price pass-through ($W\Delta OIL$) have a positive sign and have statistical significance. Moreover, the coefficients referring to the variables *CRED*1, *CRED*2, and *CRED*3 are negative and significant. In other words, the results presented confirm the hypothesis that a shock in the oil price contributes to increasing the price diffusion and that the central bank credibility has the opposite effect.

Table 5

Effect of oil price pass-through ($W\Delta OIL$) and central bank credibility on price diffusion

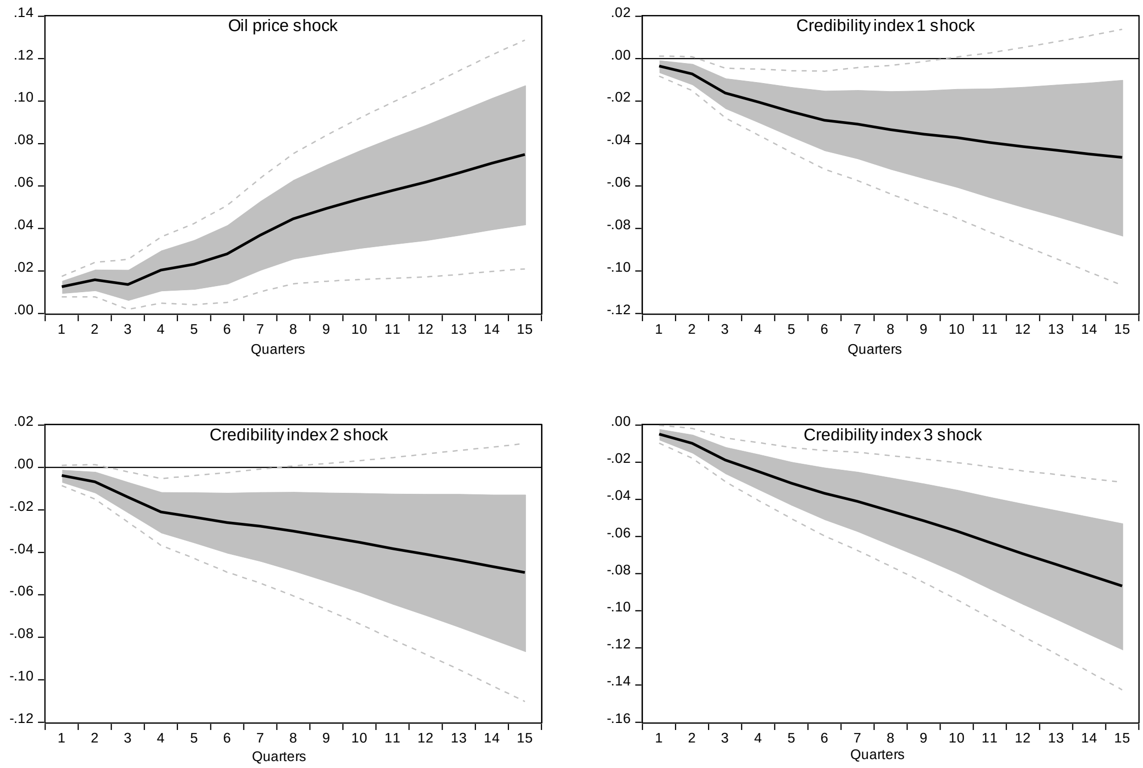
	Robust Least Squares (RLS)			System Gen. Met. of Moments (Sys-GMM)		
Regressors	Model 1 (*CRED*1)	Model 2 (*CRED*2)	Model 3 (*CRED*3)	Model 1 (*CRED*1)	Model 2 (*CRED*2)	Model 3 (*CRED*3)
$PDI_{i,t-1}$	0.764***	0.758***	0.689***	0.487***	0.521***	0.455***
	(0.025)	(0.026)	(0.027)	(0.056)	(0.059)	(0.078)
$y_{i,t} - y_{i,t-4}$	0.001	0.001	0.0004	0.002	0.001	0.002
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
$W\Delta OIL_{i,t}$	0.012***	0.012***	0.073***	0.108***	0.093***	0.098***
	(0.004)	(0.004)	(0.020)	(0.017)	(0.012)	(0.014)
$CRED_{i,t}$	-0.021***	-0.026***	-0.072***	-0.104***	-0.085***	-0.162***
	(0.009)	(0.009)	(0.013)	(0.013)	(0.024)	(0.040)
Adj. R^2	0.489	0.491	0.480			
N. Observations	648	647	675	511	511	511
N. inst./N. cross sec.				0.69	0.69	0.69
J statistic (*p-value*)				6.90 (0.44)	7.34 (0.39)	7.54 (0.37)
AR(1) (*p-value*)				-0.47 (0.00)	-0.50 (0.00)	-0.48 (0.00)
AR(2) (*p-value*)				-0.01 (0.84)	0.02 (0.70)	0.004 (0.92)

Notes: Marginal significance levels: (***) denotes 0.01, (**) denotes 0.05, and (*) denotes 0.1. Robust standard errors between parentheses (Huber – RLS, and White – Sys-GMM). RLS - constant is omitted for convenience. Sys-GMM - two-step estimation of Arellano and Bover (1995). The sample is an unbalanced panel quarterly data of 19 countries from 2002q1 to 2018q4.

Using the set of variables present in equation 5, we extended our analysis to observe the dynamic effects of a shock on the international oil price variation and the central bank credibility on the price diffusion index. Specifically, figure 2 shows the accumulated responses of the price diffusion index in the face of shocks from 1 standard deviation in the variation of the international oil price and the three central bank credibility measures. The price diffusion index's response to a shock in the international oil price shows that the effects are long-lasting and significant. After relative stability in the first three quarters, the pressure to increase the price diffusion becomes persistent. A possible explanation for this result is that as oil is an input used in the production of various goods and services, it is natural that the increase in the oil price causes a continued rise in prices as the increase in the cost of production is passed on to the final customer. The price diffusion index's responses to the shocks in the central bank credibility measures show that the impacts are negative and statistically significant. This result is consistent with the view that an increase in credibility reflects the central bank's greater ability to keep inflation under control over time and, therefore, helps prevent price increases from spreading.

Figure 2

Dynamic effects of oil price pass-through and central bank credibility on price diffusion[15]



Notes: The figure shows the accumulated responses of the price diffusion index (*PDI*) to changes in the international oil price and central bank credibility measures over 2002q1-2019q4. Confidence bands refer to a 90 percent level (dashed lines) and one standard interval (shaded area).

[15] The three measures of credibility are not included simultaneously in the model but one at a time. The graph referring to the price diffusion index (*PDI*) response to the oil price pass-through (ΔOIL) corresponds to the model that considers the credibility index *CRED*3. We did not present the *PDI*'s response to the shock over ΔOIL in the SVAR models that consider *CRED*1 and *CRED*2 because the graphs are very similar.

5. Conclusion

This study contributes to the analysis of the effect of oil price pass-through and the central bank credibility on price diffusion. Based on an analysis that considers data from 19 countries that adopt inflation targets and have central banks that disclose medium-term inflation expectations for the period 2002-2019, we find evidence that the international oil price pass-through on the price diffusion has a positive effect while credibility has a negative.

The results of the regressions in the RLS and Sys-GMM panels show that an increase in the international oil price leads to an increase in the price diffusion index. Considering the result of the Sys-GMM regressions, a shock of 1 standard deviation on the average variation in the international oil price is associated with an increase of approximately 13% in the price diffusion index. On the other hand, the shock of 1 standard deviation on the central bank credibility average leads to a 5% to 9% reduction in the price diffusion index depending on the credibility measure used in the model. Furthermore, the analysis that considers the asymmetry between increases and decreases in the oil price shows that increases are almost double the impact than reductions to explain the price diffusion. Finally, an analysis of the dynamic effects of oil price pass-through and credibility on price diffusion through an SVAR shows that both effects are long-lasting and significant. Our results allow us to conjecture that although several studies reduce the importance of oil price pass-through into inflation, its impact on price diffusion is still relevant. Therefore, it is essential to develop tools that can contain the contagion effect caused by increases in the international oil price on other prices in the economy. It is at this point that the central bank credibility proves helpful. In particular, improving strategies (such as increasing transparency) that amplify the central bank's ability to guide medium-term inflation expectations towards the announced target proves to be a beneficial tool.

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Appendix

Table A.1

Source of the series of inflation expectations

Country	Description	Source
Albania	Financial agents' inflation expectations two years ahead.	Bank of Albania
Argentina	National and foreign professional forecasters' inflation expectations two years ahead.	Central Bank of the Argentine Republic
Brazil	Market's inflation expectations two years ahead.[b]	Central Bank of Brazil
Canada	Consumer's inflation expectations two years ahead.	Bank of Canada
Chile	Two years ahead, inflation expectations of academics, consultants, and private sector executives or advisers.	Central Bank of Chile
Colombia	Financial institutions and professional analysts' inflation expectations two years ahead.	Bank of the Republic
Czech Republic	Three years ahead, inflation expectations of consumers, senior managers of industrial, construction, trade, and services companies, and analysts of national and foreign companies.	Czech National Bank
Dominican Republic	Economic analysts' inflation expectations two years ahead.	Central Bank of the Dominican Republic
Iceland	Market's inflation expectations two years ahead.	Central Bank of Iceland
New Zealand	Two years ahead, inflation expectations of analysts, economists, and industry leaders.	Reserve Bank of New Zealand
Norway	Economists' inflation expectations two years ahead.	Norges Bank
Paraguay	Two years ahead, inflation expectations of banks and other financial institutions, consulting firms, independent analysts, economic organizations, and universities.	Central Bank of Paraguay
Poland	Two years ahead, inflation expectations of financial sector analysts, representatives of universities and scientific institutes and specialists from workers' and employers' organizations.	National Bank of Poland
Serbia	Financial sector analysts' inflation expectations two years ahead.	National Bank of Serbia
South Africa	Inflation expectations for the next calendar year – an average of four agents' categories (entrepreneurs, financial agents, labor unions, and consumers).[a]	Bureau for Economic Research (BER)
Sweden	Two years ahead, inflation expectations of financial agents, labor entities, and entrepreneurs.	Prospera consulting[c]
Turkey	Inflation expectations of decision makers, experts from the financial and real sectors and professionals from academia and other institutions.	Central Bank of Republic Turkey

United Kingdom	Consumer's inflation expectations two years ahead.	Bank of England
Uruguay	Market's inflation expectations.	Central Bank of Uruguay

Notes: a. In the absence of two years ahead of inflation expectations, we use the following second calendar year's expectation as a proxy; b. In the absence of two years ahead inflation expectations, we interpolated expectations for the first and third-year calendars as a proxy; c. Private institution that conducts the research on behalf of the Sveriges Riskbank.

Table A.2

Descriptive statistics

Variable	*Mean*	*Median*	*Maximum*	*Minimum*	*Std. deviation*
PDI	0.64	0.65	0.73	0.55	0.03
ΔOIL	0.02	0.03	0.31	-0.73	0.15
WΔOIL	0.11	0.25	1.52	-3.75	0.80
$y_t - y_{t-4}$	3.77	3.71	7.09	-2.78	2.13
*CRED*1	0.59	0.56	0.84	0.37	0.13
*CRED*2	0.77	0.73	0.98	0.58	0.13
*CRED*3	0.82	0.78	0.97	0.70	0.09

Table A.3

Panel unit root tests

Im-Pesaran-Shin, Fisher-ADF, and Fisher-PP

Series	Im-Pesaran-Shin		ADF-Fisher		PP - Fisher	
	Statistic	Prob	Statistic	Prob	Statistic	Prob
$PDI_{i,t}$	-12.039	0.000	235.028	0.000	333.016	0.000
$y_{i,t} - y_{i,t-4}$	-7.897	0.000	147.876	0.000	196.051	0.000
ΔOIL_t	-28.702	0.000	593.771	0.000	589.925	0.000
$CRED1_{i,t}$	-2.895	0.002	79.132	0.000	121.500	0.000
$CRED2_{i,t}$	-6.321	0.000	120.038	0.000	144.462	0.000
$CRED3_{i,t}$	-4.954	0.000	101.641	0.000	137.064	0.000

Notes: Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality. Automatic lag difference term and bandwidth selection (using the Schwarz criterion for the lag differences, and the Newey-West method and the Bartlett kernel for the bandwidth). Exogenous variables: individual effects.

Table A.4

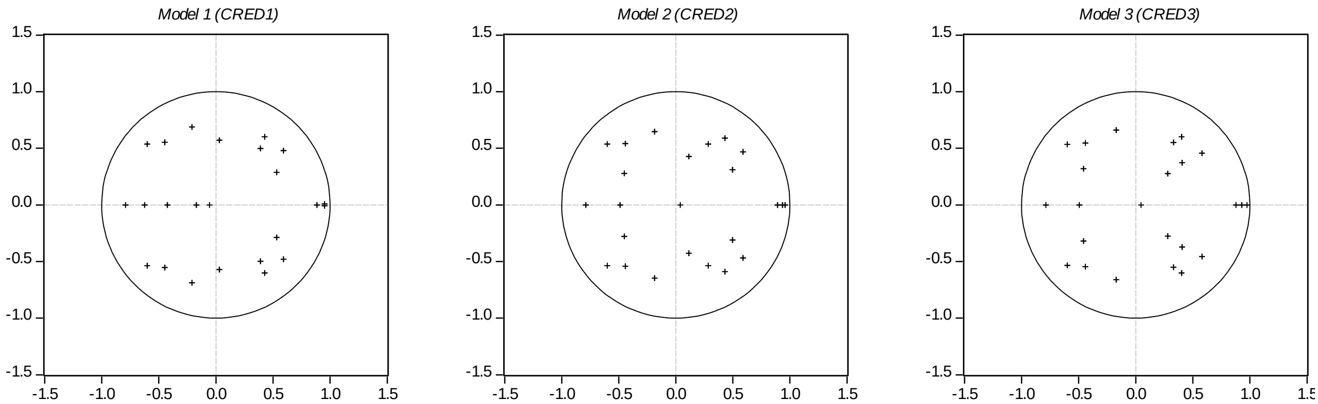
VAR lag order selection criteria

	Model 1 (*CRED*1)			Model 2 (*CRED*2)			Model 3 (*CRED*3)		
Lag	LR	FPE	AIC	LR	FPE	AIC	LR	FPE	AIC
0	NA	0.0003	3.275	NA	0.0003	3.226	NA	0.0001	2.427
1	241.880	9.31e-06	-0.233	2096.634	1.07e-05	-0.094	2481.630	2.59e-06	-1.512
2	128.801	7.97e-06	-0.388	132.762	9.08e-06	-0.258	114.547	2.27e-06	-1.646
3	53.715	7.69e-06	-0.424	54.104	8.75e-06	-0.295	51.033	2.19e-06	-1.678
4	76.346	7.15e-06	-0.497	78.863	8.09e-06	-0.373	91.526	1.99e-06	-1.777
5	125.186	6.13e-06	-0.651	128.851	6.88e-06	-0.535	124.981	1.70e-06	-1.933
6	38.951*	6.05e-06*	-0.664*	34.428*	6.84e-06*	-0.541*	31.781*	1.70e-06*	-1.934*
7	17.242	6.18e-06	-0.642	16.010	7.01e-06	-0.517	23.055	1.72e-06	-1.922

Notes: LR - sequential modified LR test statistic (each test at 5% level). FPE – Final prediction error. AIC – Akaike information criterion. (*) denotes lag order selected by the criterion.

Figure A.1

Inverse roots of AR characteristic polynomial



Notes: No root lies outside the unit circle. Var satisfies the stability condition.