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Energy Price Shocks and Financial Market Integration: Evidence from New Keynesian Model

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Abstract The purpose of this study is to examine the impact of oil price shocks on economic activity. A dynamic stochastic general equilibrium model was applied to verify the role of international financial integration in a New Keynesian model when the oil price shocks hit the economic system. The key findings show that more financial integration tends to dampen the effect of an increase in the oil price than less financial integration. The sensitivity analysis shows that increased elasticity of substitution between oil and domestic goods allows importing countries to reduce their dependence on oil. Financial integration plays an important role in reducing the oil shock effect.

Keywords Oil price shocks · Financial integration · New Keynesian model · DSGE

JEL Classification E32 · F4 · Q43

Introduction

The most likely scenario is that oil prices will continue to recover from just $25 per barrel in January 2016 to $45 per barrel in the spring of 2016, rising to about $60 per barrel in spring 2017 (Artus 2016). As global oil demand increases by about 2% per year, half of which is due to the world's population growth and the other half to the low oil price, the world's production of oil has remained more or less constant (Artus 2016).

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Production in Iran, for example, was offset by lower production in the United States (U.S.), while production in other countries remained more or less stable.

If this assumption of a continued increase in oil prices is correct, then all the consequences for economies, monetary policy, and financial markets must be evaluated (Artus 2016). Energy-importing countries, whether they are Organisation for Economic Cooperation and Development countries (e.g., Europe, Japan) or emerging countries (e.g., India, China, Turkey, South Africa, and some European countries), will be affected negatively by rising costs to imported energy, and the resulting rise in inflation will curb consumption. Oil- and gas-producing countries (e.g., Organization of the Petroleum Exporting Countries (OPEC), Russia, Brazil, Mexico, Chile, Colombia, Peru, Indonesia, Africa, Canada, Australia), meanwhile, will witness an increase in growth instead. The only complicated case is then that of the U.S., which is understood to have become an oil country.[1] Since then, numerous efforts have been made that were devoted to studying the transmission mechanisms for the impact of oil price changes, as well as more importantly what people should do to alleviate the negative effects brought about by drastic changes in oil prices.

Unexpected capital movements are a second potential source of disturbance to a national economy because, through affecting the money supply, they can stimulate the economy in an inflationary way in the case of full employment or trigger a recession. The ultimate effect depends upon the exchange rate system and monetary policy being used.

In a fixed exchange rate regime, a successful neutralization policy can prevent massive inflows or outflows of capital from impacting the money supply and national economic activity. A passive monetary policy, meanwhile, means that the movement of funds influences the national money supply and the economic activity.

In a flexible exchange-rate regime, the impact of unexpected movement of funds in the economy depends on the elasticity of demand from agents, as well as the monetary policy. For example, depreciation caused by unexpected capital outflows tends to increase the surplus, or reduce the deficit, in the current account balance and stimulate domestic production, at least if the elasticity is favorable and the central bank chooses to neutralize the initial reduction in the money supply. Should the central bank remain passive, the ultimate net effect of the capital outflows would depend on the negative consequences of the reduction in the money supply and the positive effects that depreciation brings about.

Since the 1970's, which saw severe oil shocks, a great deal of effort has been made to investigate the many implications of high oil prices on countries' economies. However, to the best of my knowledge, no work has sought to study the impact of oil price shocks in the presence of financial integration using a dynamic general equilibrium model.[2] In theory, it can be shown that financial integration plays two distinct roles in transmitting oil shocks (Kilian et al. 2009). On the one hand, this helps share the risk between oil-exporting and oil-importing countries. Increases in oil price can also be mitigated when agents of oil-importing countries own oil assets. This also helps spread the risks that come with shocks to the world's crude oil markets. This also

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[1] In the United States, rising oil prices have a positive effect on the energy sector (through revenues, employment, and investment) and related services (oil services, metallurgy) that now prevail with the appearance of shale gas and oil, but they have a negative effect on consumption.

[2] Sutherland (1996) showed how the new open standard macroeconomic model can be extended to analyze the implications of global financial market integration for the impact of monetary, fiscal and productivity shocks on macroeconomic volatility but not oil price shocks unfortunately.

gives oil-exporting countries some insurance against falling oil prices. On the other hand, financial integration influences how the adjustment liability is spread across oil-importing economies, with not every country benefiting from greater international financial integration. In this way, Kilian et al. (2009) show that the U.S. is in an especially unique and privileged position, because net foreign assets tend to help it respond to high-demand shocks in the global crude oil market, while other oil-importing economies with less foreign assets may not fare as well with the same shocks.

Many papers have analyzed the potential role of oil price shocks regarding macroeconomic fluctuation (e.g. Kim and Loungani 1992; Finn 1995; Dhawan and Jeske 2006; Vasconez et al. 2015; Zhao et al. 2016). They have not considered the role that financial integration can play in this relationship. Some studies (Sutherland 1996; and Ghazouani et al. 2019) analyzed the implications of global financial integration for the impact of monetary, fiscal and productivity shocks on macroeconomic volatility but not oil price shocks. By contributing to filling this gap, the objective of this paper is to analyze the impact of oil price shocks on economic activity and the role of international financial integration.

To examine this relationship, the paper closely follows the New-Keynesian model of Vasconez et al. (2015) by introducing foreign bonds into a household's budgetary constraints to investigate the role that financial market integration can play in studying the impact of rising oil prices on the real economy. This model also accounts for the various effects of capital accumulation. There are strong theoretical and empirical arguments that suggest that current account behavior is mainly determined by capital accumulation (Sachs 1981; Baxter and Crucini 1993). Indeed, Sutherland (1996) posits that the performance of capital stocks will probably have important consequent implications for the influence of financial market integration. Concurrently, capital can potentially act as a fresh channel for monetary policy, considering the non-arbitrage relationships between the capital borrowing rate, a central bank interest rate, and above all, the role of capital efficiency in softening any impact from oil price rises (Vasconez et al. 2015).

Literature Review

Hamilton (1983) initiated a study into the influence of oil prices on gross domestic product (GDP) with the intention of measuring the impact of oil prices on economic aggregates in the U.S.. Considering the oil price as an exogenous variable, he discovered that since the Second World War, substantial oil price increases have always been followed by recessions with a considerable impact on GDP in the U.S.. Some later studies that also included the 1979–80 oil price shock backed up this finding. For example, Ratti and Vespignani (2016), Lardic and Mignon (2006), Jimenez-Rodriguez and Sanchez (2005), Cunado and de Gracia (2005), Papapetrou (2001), Ferderer (1996), Lee et al. (1995), Mork et al. (1994), Mork (1989), Gisser and Goodwin (1986), and Burbridge and Harrison (1984) all revealed the consistently negative effects of oil prices on the GDP of industrialized and industrializing countries, as well as oil-importing and oil-exporting economies. What is more, the various effects appear surprisingly alike for different developed countries. A much more limited body of literature (e.g., Bruno and Sachs 1982; Ostry and Reinhart 1992; Gavin 1990, 1991) studied the effects of oil price shocks on external accounts.

In their real business cycle (RBC) model, Kydland and Prescott (1982) showed how aggregate fluctuations in macroeconomics could be explained through a competitive model without any externalities. Since then, this model has been extended in numerous ways in various studies.

The energy price, in addition to technological shocks, is another potential factor that can be considered as a major force driving macroeconomic fluctuations. Kim and Loungani (1992) were the first to take the energy price shock into account in the RBC model. In this model, energy was considered another production factor of the firm sector, with it being exogenous and following an ARMA stochastic process. Kim and Loungani compared an RBC model that takes into account the energy price and technology shocks with one using only technology shocks. They showed that the model with both shocks could explain more of the output fluctuation. On the other hand, though, their results failed to replicate the main cyclical properties seen in the actual U.S. data when the RBC model considered the energy price shock only. In short, the main finding of Kim and Loungani's (1992) study is that energy price plays a significant role in explaining aggregate fluctuations and their impact on macroeconomic variables.

Another strand of the literature studies the introduction of the energy price into the model (Finn 1995). Based on the high correlation between the growth rate of the real energy price and the aggregate Solow residual in the U.S. economy, Finn (1995) sought to demonstrate in his RBC model how an economy's productivity could be affected by energy price shocks. He multiplied the capital input by a utilization rate rather than directly putting the energy usage into the production function as an input. The linkage between the energy price and productivity, for Finn, is as follows: the energy use in each period affects the ratio of energy-capital. A change in the latter would further lead to variations of the capital utilization rate. Through his results, Finn demonstrated that the combination of energy price shocks, technology shocks, and government expenditure shocks could generally mimic the cyclical properties of the postwar U.S. economy.

Dhawan and Jeske (2006) highlighted how in an earlier model that mostly employed energy from the perspective of production only, energy shocks only accounted for a negligible portion of output fluctuations. In order to establish the robustness of earlier findings, the authors extended Kim and Loungani's (1992) RBC model by explicitly modeling, in addition to firm-level energy use, private energy use by households to derive the total energy used in the economy. They also distinguished between investments in consumer durables and capital goods.

Dhawan and Jeske (2006), in their study, came to the primary conclusion that energy price shocks do not have a major influence on business cycle fluctuations, even when considering three different types of consumption, namely durables, non-durables, and energy. The results of their simulation indicate that despite the greater energy used in total, the economy shows that even less of the output fluctuations can be attributed to energy price shocks. Productivity shocks, meanwhile, seem to be the driving force behind business cycle fluctuations. These results derive from how households now have an ability to rebalance their investment portfolios. In other words, an energy price hike is mitigated by reducing investment in durable goods more than in capital goods, thus softening any hit to future production at the expense of present consumption. As such, in this model, a household in their model can mitigate the drop in output by adjusting its durable goods margin rather than just its fixed capital. This rebalancing means that productivity shocks continue to be the driving force for output fluctuations.

They further show that an increase in the energy price has a greater negative effect on durables than on fixed capital. Even though both capital stocks will decrease in a reaction to higher energy prices, once households rebalance their portfolios, the fixed capital drops less than the stock of durables does. Furthermore, the drop in fixed capital is lower than in the type of economy proposed by Kim and Loungani (1992), which explains why energy prices account less for output fluctuation in the model. Again, productivity shocks alone seem to mainly account for output fluctuations.

Another extension of the RBC model with energy was proposed by Huynh (2015), who developed a multi-sector model with endogenous energy production. The objective was to explore the implementation as an additional step in the theoretical efforts to model energy in macroeconomics. The model covers multiple sectors, and introduces energy as something produced endogenously. It also explicitly models durables in the household utility to function. All agents in the economy rely on energy, whether it is for the consumption of household durables or for production of various goods. All these elements enable the analysis of how the effects of changing energy prices are transmitted through the economy and, in particular, the impact on overall output and on durables consumption and production. Overall, the model is quite successful at replicating the aggregate behaviors of the economy in the event of an adverse energy price shock from the supply side. It is able to model large impacts on overall output, emphasizing the important role that energy plays. In the results, Huynh (2015) observes the significant effects of a supply-side shock in energy prices for the overall economy, confirming the important role of energy for both households and producers. Insights were also gained about the interplay among different production sectors when such shocks hit, as well as the feedback carried into the production of energy by changing energy demands, since the energy price is no longer exogenously imposed upon agents in the economy but rather endogenously determined.

To overcome the conflict between the RBC model with its completely flexible price and the large amount of empirical evidence that indicates that monetary disturbances have substantial real effects, economists have built a general equilibrium model that can explain the business cycle phenomenon, both qualitatively and quantitatively. This model takes into account the New-Keynesian assumptions, such as monopolistic competition, nominal rigidities and the short-term non-neutrality of monetary policy.

Leduc and Sill (2004) introduced energy into a New-Keynesian model to study the impact of oil price shocks and compare them with the effects of different monetary policies. They sought to investigate whether it was the oil price shock itself or the endogenous monetary policy that led to the phenomenon where recessions in the postwar U.S. economy are always preceded by an increase in oil price. Leduc and Sill extend Finn's (1995) model with three optional policies to allow the central bank to target the price level, interest rate, or inflation rate. They found that the impulse responses of the oil price shock were substantially different for these three monetary policies. The monetary policy targeting the price level gave the best performance in mitigating the negative effect of oil price shocks. In contrast, the monetary policy targeting the inflation rate seemed to only make the situation worse. This study therefore concluded that the central bank's monetary policy did play a crucial role in reacting to oil price shocks.

Recently, Vasconez et al. (2015) introduced energy into an otherwise standard New-Keynesian model, much like Blanchard and Gali (2009) and Blanchard and Riggi (2013), in order to investigate two well-known, stylized facts: (1) the stagflationary impact of an oil price shock and (2) the influence of the energy efficiency of capital on its depth and duration. The authors estimated and simulated their New-Keynesian model with capital accumulation, which used the case of an oil-importing economy where the abovementioned stylized facts can be accounted for. They used a Bayesian estimation to solve the model for the U.S. economy from 1984 to 2007. Its results imply an output elasticity for oil possibly in excess of 10%, stressing the role that oil use played in U.S. economic growth over the studied period. The authors' simulations also confirm, however, that increases in energy efficiency significantly weakens the impact of an oil shock, possibly explaining why the third oil shock (1999–2008) lacked the same macroeconomic impact as the first two oil shocks. Combined, these two findings suggest that oil consumption and energy efficiency have been major drivers for U.S. growth over the previous three decades.

In a very recent study, Zhao et al. (2016) established an open-economy dynamic stochastic general equilibrium (DSGE) model for two economies, namely China and the rest of the world. To evaluate the influences of oil price shocks, Zhao et al. (2016) added oil as an input to the CES production function. Based on this model, they evaluated the effects of four types of oil price fluctuation: (i) supply shocks triggered by political events in OPEC-member countries, (ii) other oil supply shocks, (iii) aggregate shocks to the demand for industrial commodities, and (iv) shocks in the demand for the crude oil market. The simulation's results suggest that oil supply shocks caused by political events mainly resulted in short-lived effects on output and inflation in China, while the remaining types of shock had relatively long-term effects. What is more, demand shocks in the crude oil market contributed the most to the fluctuations in China's output and inflation.

A New-Keynesian Economy with Financial Market Integration

Like Vasconez et al. (2015), who followed the example of Blanchard and Gali (2009) and Blanchard and Riggi (2013), energy is imported from aboard at an exogenous world price. The final output is destined for domestic consumption or export, such that oil imports are offset by these exports. It is assumed that the balance of trade is indeed balanced at every date, so exports adjust to the cost of imports. In this model, households consume oil (energy) and the intermediate goods use it as a supplementary input in the process of its production.

Household

All agents are identical and the population size is normalized to one, so that national aggregates and per capita quantity variables are the same. The home representative agent's intertemporal utility function is additively separable over time. This is given by:

$$U_t = E_t \sum_{s=t}^{\infty} \beta^{s-t} u_s, \tag{1}$$

where

$$U(C_t, N_t) = \ln(C_t) - \frac{N_t^{1+\tau}}{1+\tau}, \tag{2}$$

where E_t is the expectation based on all the available information for period t, while C_t is the consumption at time t, $N_t$is labor, and τ is the inverse of the Frisch elasticity. The parameter β denotes the home agent's subjective discount rate, which measures the value of future consumption in terms of present consumption, where the consumption flow is defined as:

$$C_t = \Theta_x C_{e,t}^{x} C_{q,t}^{1-x}, \tag{3}$$

and where x is the share of oil in consumption and $\Theta_x = x^{-x}(1-x)^{-(1-x)}$.

In Blanchard and Gali (2009), indeed, the consumption price index (CPI) is defined as $P_{c,\ t}$, the core CPI, as $P_{q,\ t}$ and the GDP deflator, as $P_{y,\ t}$. In that paper, the three indices are related by the following equations:

$$P_{q,t} = P_{y,t}^{1-\gamma} P_{e,t}^{\gamma} \tag{4}$$

$$P_{c,t} = \mathrm{P}_{q,t}^{1-x} P_{e,t}^{x}. \tag{5}$$

As a consequence of (4):

$$P_{y,t} = P_{q,t}^{\beta} P_{e,t}^{1-\beta} \tag{6}$$

where $\frac{P_{e,t}}{P_{q,t}}$ is the (exogenous) real price of energy at time t, γ (the oil output elasticity), $x \in (0,1)$ and $\beta > 1$.

These conventions have the paradoxical consequence that when the energy price experiences an upward shock, the GDP deflator decreases (with everything else being kept the same) as can be seen in (6). Vasconez et al. (2015) fix this problem by imposing $P_{y,\ t} \equiv P_{c,\ t}$ while keeping (5) and the following budget identity that defines GDP, in the left-hand side as an aggregation of domestic product minus energy import:

$$P_{y,t} Y_t = P_{q,t} Q_t - P_{e,t} E_t.. \tag{7}$$

The optimal allocation of expenditures among different domestic goods yields:

$$P_{q,t} C_{q,t} = (1-x) P_{c,t} C_t, \tag{8}$$

$$P_{e,t}C_{e,t} = xP_{c,t}C_t. \tag{9}$$

Financial Market Integration

In this model, the domestic agent has two forms of financial assets: home and foreign bonds. This agent can trade home bonds in the home financial market without cost, but the agent pays transaction costs when trading foreign bonds in foreign financial markets. These transaction costs for foreign bonds are given by:

$$X_{f,t} = \frac{\varphi_f}{2} I_{f,t}^2 \tag{10}$$

where φ_f is a positive parameter, while $I_{f,\ t}$ is the funds moved from the home to the foreign bond market in period t. $X_{f,\ t}$ and $I_{f,\ t}$ are denominated in terms of composite consumption goods. The convex form of the transaction costs represented in eq. (10) implies that the transaction costs for the foreign financial markets will lead to decreasing returns to scale. The implication here is that the lower the transaction costs (i.e. low φ_f) are, the greater the degree of financial market integration there will be. The evolution of foreign bond holding (F_t) is given by:

$$F_t = \left(1 + i_{t-1}^*\right) F_t + P_{c,t}^* I_{f,t} \tag{11}$$

with i_{t-1}^* denoting the foreign nominal interest rate paid to hold a foreign bond between period t-1 and t.

Following the example of Vasconez et al. (2015), the household invests a fraction of its income in capital stock in each period, so according to the law of motion, capital accumulates:

$$K_{t+1} = (1-\delta)K_t + I_{k,t}, \tag{12}$$

where K_{t+1} represents the stock of capital accrued by the end of period t, while $I_{k,t}$ signifies the gross capital investment. For each period, the agent invests in physical capital while loaning the existing capital stock to firms at $r_{k,\ t}$, which is the real interest rate per unit of capital. Physical capital, meanwhile, reduced in value at a constant rate of δ, ($0 < \delta < 1$). In contrast to several DSGE models, the capital price is not related to the consumption price but is rather viewed as something subject to outside factors (Vasconez et al. 2015). Indeed, as is well-understood from the Cambridge controversy, the practice of connecting consumption and capital prices derives from the lack of an equilibrium condition that would allow defining the market value of capital. This simple identification, however, excludes the capturing of unconnected bubble phenomena, such as the housing bubble that affected many western countries from the mid-1990s (e.g., Bonnet et al. 2014). The intertemporal budget constraint for each home agent is written as:

$$P_{q,t}C_{q,t} + P_{e,t}C_{e,t} + P_{k,t}[K_{t+1}-(1-\delta)K_t] + B_t + S_tF_t \tag{13}$$

$$\leq (1 + i_{t-1}) B_{t-1} + S_t \left(1 + i^*_{t-1}\right) F_{t-1} + P_{k,} r_{K,t} K_t + W_t N_t + D_t + T_t,$$

where T_t stands for taxation, W_t is nominal wages, D_t is profits from the ownership of all intermediate good, i_{t-1} is nominal home interests for home bonds B_t between $t-1$ and t,; i^*_{t-1} is nominal foreign interests for foreign bonds (F_t) (denominated in foreign currency) between t and $t-1$. S_t is the nominal exchange rate (defined as the price of the foreign currency in terms of the home currency).

Household aims to maximize her lifetime discounted utility function (1) under the budget constraint (13) yields the following first order conditions for $\{C_t,\ N_t, B_t, F_t \ and \ K_{t+1}\}_{s=t}^{\infty}$

$$C_t = \lambda_t P_{c,t} \tag{14}$$

$$C_{t+1} = \left[\beta E_t (1 + i_t) \frac{P_{c,t}}{P_{c,t+1}}\right] C_t \tag{15}$$

$$N_t^{\tau} C_t = \frac{W_t}{P_{c,t}} \tag{16}$$

$$\left(1 + \psi_f I_{f,t}\right)(1 + i_t) = E_t \frac{S_{t+1}}{S_t} \left(1 + i^*_t\right)\left(1 + \psi_f I_{f,t+1}\right) \tag{17}$$

$$\lambda_t P_{k,t} = E_t \beta \lambda_{t+1} \left[\left(r_{K,t+1} + (1-\delta)\right) P_{k,t+1}\right] \tag{18}$$

Representative Finished Goods-Producing Firm

A representative finished goods-producing firm uses the output of intermediate firms as input to produce final goods. These final goods will be resold to households or exported in exchange for oil. There is a continuum, [0, 1], of intermediate goods that serve in producing the consumption commodity. A final good firm maximizes its profits in a perfectly competitive market. This firm has a constant returns to scale (CRS) technology like:

$$Q_t = \left[\int_0^1 Q_t(z)^{\frac{\vartheta-1}{\vartheta}} dz\right]^{\frac{\vartheta}{\vartheta-1}}. \tag{19}$$

In order to maximize its profit, the final good firm chooses quantities, $Q_t(z)$, of intermediate goods. $\vartheta > 0$ by assumption and represents the elasticity of substitution among intermediate goods.

Taking the final goods price $P_{q,\ t}$ and intermediate goods price $P_{q,\ t}(z)$ as given, the demand function of the representative finished goods-producing firm for intermediate goods is the following, where ϑ denotes the price elasticity of demand for intermediate goods z:

$$Q_t(z) = \left(\frac{P_{q,t}(z)}{P_{q,t}}\right)^{-\vartheta} Q_t. \tag{20}$$

Since the market of the representative finished goods-producing firm is perfectly competitive, the following zero profit condition of $P_{q,\ t}$ needs to be satisfied:

$$P_{q,t} = \left[\int_0^1 P_{q,t}(z)^{1-\vartheta} dz\right]^{\frac{1}{\vartheta-1}} \tag{21}$$

Representative Intermediate Goods-Producing Firm

Taking prices, $P_{k,\ t}$, $P_{e,\ t}$, $r_{k,\ t}$, W_t, and demand $Q_t(z)$ as given, each intermediate good firm z chooses quantities of labor $N_t(z)$, capital $K_t(z)$, and oil $E_t(z)$ so as to minimize its cost.[3] Each firm has the same production function, which is given by:

$$Q_t(z) = A_t K_t(z)^{\alpha} N_t(z)^{\beta} E_t(z)^{\gamma} \tag{22}$$

$$\alpha, \beta, \gamma \geq 0,$$

where $K_t(z)$, $N_t(z)$ and $E_t(z)$ stand for capital, labor and oil inputs, respectively. A_t is the exogenous technology shock and follows the autoregressive processes (AR(1)) described as:

$$ln\,A_t = \rho_a lnA_{t-1} + \varepsilon_{a,t}\, where\, \varepsilon_{(a,t)}\ N\left(0, \sigma_a^2\right).$$

Hence is assumed to follow the marginal cost pricing behavior, which is characterized by the (standard) first-order conditions:

$$mc_t(z) = \frac{r_{k,t} P_{k,t}}{\alpha \dfrac{Q_t(z)}{K_t(z)}} = \frac{W_t}{\beta \dfrac{Q_t(z)}{N_t(z)}} = \frac{P_{e,t}}{\gamma \dfrac{Q_t(z)}{E_t(z)}}.$$

So, the marginal cost is such as:

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[3] Returns to scale need not be decreasing (i.e $\alpha + \beta + \gamma$ will possibly be larger than one).

$$mc_t(z) = X_t Q_t(z) \frac{1}{\alpha + \beta + \gamma}. \tag{23}$$

with

$$X_t = \left[\frac{A_t \alpha^{\alpha} \beta^{\beta} \gamma^{\gamma}}{\left(r_{k,t} P_{k,t}\right)^{\alpha} W_t^{\beta} P_{e,t}^{\gamma}} \right]^{\frac{-1}{\alpha+\beta+\gamma}}.$$

Furthermore, in order to import the New Keynesian sticky price feature into the model, it is assumed that the representative intermediate goods firm adjusts its price in a staggering manner, as in Calvo (1983). Specifically, in period t, each intermediate goods firm has the probability of $(1 - \theta_p)$ to reset its price (with, $P_{q,t}(z) = P^i_{q,t}$), and has probability θ_p of maintaining the current price level inherited from the previous period (i.e $P_{q,\ t}(z) = P_{q,\ t-1}(z)$).

Hereby, the dynamics of the aggregate price level are described by:

$$P_{q,t} = \left[\theta_p P_{q,t-1}^{1-\sigma} + \left(1-\theta_p\right) \left(P^i_{q,t}\right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}. \tag{24}$$

The objective of the firm is to choose the price level in period t so as to maximize the discounted value of current and future profits with each future period weighted by the probability that the current price will still be in force in that period. Firm z's maximand is thus:

$$\max_{P_{q,t}(z)} E_t \left[\sum_{k=0}^{\infty} \theta_p^k R_{t,t+k} \left[P_{q,t}(z) Q_{t,t+k}(z) - cost\left(Q_{t,t+k}(z)\right)\right] \right]. \tag{25}$$

subject to

$$Q_{t,t+k}(z) = \left[\frac{P_{q,t}(z)}{P_{q,t+k}} \right]^{-\sigma} Q_{t+k}.$$

Again, this problem does not depend on z, hence $P_{q,t}(z) = P^i_{q,t}$. From the first order condition $P^i_{q,t}$ there is:

$$E_t \left[\sum_{k=0}^{\infty} \theta_p^k R^i_{t,t+k} \left(P^i_{q,t} - \Gamma_p mc^i_{t,t+1} \right) \right] = 0, \tag{26}$$

with $\Gamma_p = \frac{\sigma}{\sigma-1}$ is the price markup and $R_{t,\ t+k}$ is the discount factor between time t and time $t + k$.

Government

The government budget constraint is:

$$(1 + i_{t-1})B_{t-1} + G_{n,t} = B_t + T_t, \tag{27}$$

where $G_{n,\ t}$ is the nominal government spending. Like Vasconez et al. (2015), the real government spending $G_t = \frac{G_{n,t}}{P_{q,t}}$ is assumed to follow an exogenous autoregressive processes:

$$ln\ G_t = \left(1-\rho_g\right)\ln\left(\omega\overline{Q}\right) + \rho_g ln\ G_{t-1} + \rho_{ag}\varepsilon_{a,t} + \varepsilon_{g,t}, \tag{28}$$

where $\varepsilon_{g,t}{\sim}N(0, \sigma_a^2)$, ω and $\overline{Q}$ are the share of output that the government takes for its own spending and the steady state of domestic output, respectively.

Central Bank

The central bank in this model carries a monetary policy by setting the nominal short-term interest rate according the following relationship:

$$\frac{1 + i_t}{1 + \overline{i}} = \left(\frac{\Pi_{q,t}}{\overline{\Pi}}\right)^{\Phi_\pi}\left(\frac{Y_t}{\overline{Y}}\right)^{\Phi_y}\varepsilon_{i,t}, \tag{29}$$

where $\mathit{\Pi}_{q,\ t}$ stands for core inflation. $\overline{i}$, $\overline{\mathit{\Pi}}$ and $\overline{Y}$ represent the steady state values of i_t, $\mathit{\Pi}_{q,\ t}$ and Y_t. The endogenous money policy mechanism can be described as:

$$ln\varepsilon_{\mathrm{i},t} = \rho_i ln\varepsilon_{i,t-1} + \mu_{i,t}, . \tag{30}$$

$\mu_{i,\ t}$ represent the independent and identically distributed (i.i.d.) shock and ρ_i is the shock persistence parameter.

Market Clearing and Consolidated Budget Constraint

In equilibrium, all goods and factor markets have to clear, i.e., the following equations hold: Capital: $\int_0^1 K_t(z)\partial z = K_t$ Labor: $\int_0^1 N_t(z)\partial z = N_t$ Energy: $\int_0^1 E_t(z)\partial z = E_t$. The household budget constraint: $P_{c,\ t}C_{q,\ t} + P_{k,\ t}I_{k,\ t} + G_t + S_tI_{f,\ t} = P_{q,\ t}Q_t - P_{e,\ t}E_{e,\ t}$. The government budget constraint: $(1 + i_{t-1})B_{t-1} + G_{n,\ t} = B_t + T_t$

Calibration Processes

To derive testable implications for the impact of oil price shocks on macroeconomic variables under financial integration, the model was solved numerically. In the first step, Vasconez et al. (2015) and Blanchard and Riggi (2013) were followed, log-linearizing the model around its steady state. In the second step, the model was simulated numerically. In order to simulate the model, all the parameters in this model need to be assigned. In this study, these parameters were assigned according to the estimation and calibration results in Vasconez et al. (2015) except the parameter relating to the financial markets integration (φ_f) from Sutherland (1996). It assumed that $\varphi_f = 0.01$ when an economy is more financially integrated and $\varphi_f = 4$ when it is less financially integrated. Table 1 summarizes all the calibrated parameter values used in the simulations.

Simulations and Results

Our economy consists of two groups: the most financially integrated (MFI) economies and the least financially integrated (LFI) ones. Each economy is subject to several potential exogenous shocks, which are: government expenditure, monetary policy, real price of oil, real price of capital, price markup and the technology. These shocks are log-normally distributed as follows: Budgetary policy shock $g_{r,\ t} = \rho_g g_{r,\ t-1} + \rho_{ag}\mu_{a,\ t} + \mu_{g,\ t}$, Monetary policy shock: $\varepsilon_{i,\ t} = \rho_i \varepsilon_{i,\ t-1} + \mu_{i,\ t}$, Oil price shock: $h_{e,\ t} = \rho_{he} h_{e,\ t-1} + \mu_{he,\ t}$, Capital price shock: $h_{k,\ t} = \rho_{hk} h_{k,\ t-1} + \mu_{hk,\ t}$, Price markup shock: $\varepsilon_{p,\ t} = \rho_p \varepsilon_{p,\ t-1} + \mu_{p,\ t} - \Phi_p \mu_{p,\ t-1}$, Technology shock: $a_t = \rho_a a_{t-1} + \mu_{a,\ t}$ where $\varepsilon_{i,\ t}$ stands for the exogenous part of the monetary policy and $\varepsilon_{p,\ t}$ and stands for the price mark-up disturbance, which is assumed to follow an ARMA(1,1). For the *raison* of the study, I concentrated solely on the real price of oil shock to find out its macroeconomic effects on every economy in the following.

Oil Price Shock Effect in an MFI Economy

This section presents the response functions found following the model simulation in the context of a flexible exchange rate regime with inflation targeting in an MFI economy. The impulse response functions (IRFs) illustrated in Figs. 1, 2, and 3, show that the impact of an oil price shock triggers a persistent drop in consumption, output, and investment, which subsequently converges to the respective steady states. Several works have proved these results empirically. For instance, Hamilton (2003), Herrera and Karaki (2015), and Karaki (2017) showed a significant relationship between higher oil prices and lower economic activity. Similarly, a negative impact of oil price shocks on aggregate consumption has been confirmed by several investigations (e.g., Bokan et al. 2018; Baumeister et al. 2018; and Alsalman and Karaki 2019). For the oil price shocks on investment, the result is consistent with Lee et al. (2011) who found a negative impact of oil price shocks on aggregate investment, a result supported by Kilian (2014). This result can be explained through the combination of the two effects of rising oil prices: a direct effect across the balance of payments and an indirect effect on production through increased production costs.

In fact, firms tend to use less and less of their capital and this will result in a decline in worker productivity. This fall in productivity is accompanied by a decrease in wages which will push households to substitute work for leisure (see the Online Supplemental

Table 1 Calibrated parameter values

Descriptions	Notations	Values
Subjective discount rate	β	0.99
Inverse of the Frisch elasticity	τ	1.17
Share of oil in consumption	x	0.023
Transaction costs for taking positions in international foreign market if capital is high (low)	φ_f	0.01 (4)
Capital depreciation rate	δ	0.025
Elasticity of substitution among intermediate goods	ϑ	8
Capital share in production	α	0.3
Labor share in production	β_l	0.7
Oil share in production	γ	0.11
Probability that firm cannot reset price	θ_p	0.96
Price murkup	Γ_p	1.14
Government spending output share	ω	0.18
Interest rate coefficients on inflation	Φ_π	1.2
Interest rate coefficients on output	Φ_y	0.5
Shock persistence parameter	ρ_j	0.5
Variance of the shock[a]	σ_j^2	1

Source: Vasconez et al. (2015) and Sutherland (1996)

[a] $j \in \{he, hk, a, p, i, g\}$

Appendix for the impulse response functions (IRFs) of these macroeconomic aggregates). Given that it is an MFI economy, and the adjustment costs are therefore less important ($\varphi_f = 0.01$)), agents are inclined to acquire more foreign assets in order to smooth their consumption following an oil price shock. The instantaneous effect of an oil price shock on foreign bonds is shown in the Online Supplemental Appendix. The increase in these assets can be explained by how agents turn to the international markets to acquire foreign bonds to increase their income and smooth their consumption, resulting in a smaller increase in consumption, as shown in Fig. 1.

As the domestic oil price is included in the composition of the Consumer Price Index (P_c), the increase in global oil price leads to an increase in the inflation rate ($\pi_c = 2\%$), which will trigger an increase in the nominal interest rate (see the Online Supplemental Appendix). This result is consistent with the findings of Zhao et al. (2016), who found a short-term effect on inflation produced by an oil supply shocks.[4] This nominal interest rate increase leads to a broad appreciation of the nominal and real exchange rate. The intuition behind this significant exchange-rate appreciation is as follows: Under a flexible exchange rate system with inflation targeting, the goal is to keep a stable rate of inflation. To do this, the increase in the nominal interest rate must necessarily engender an appreciation of the nominal and real exchange rate in order to absorb fluctuations in the inflation rate caused by higher oil prices.

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[4] Zhao et al. (2016) show that the supply shocks driven by political events in OPEC countries have a very limited impact on China's output and inflation due to their short-term nature.

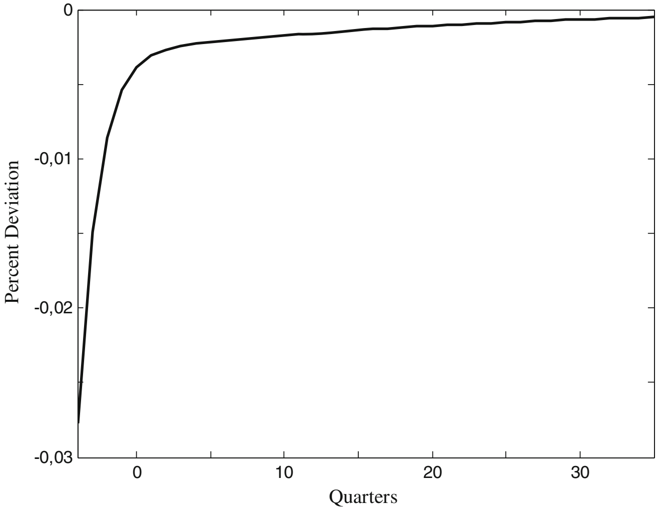

Fig. 1 Responses of consumption to one standard deviation shock on oil real price. Case MFI economy. Sources: Authors' own calculations based on model simulation

Effect of Oil Price Shock in an LFI Economy

In this section, the impulse responses of a permanent increase are analyzed in a one unit of an oil price shock in the case of an LFI economy (i.e., when the transaction costs are high, $\varphi_f = 4$ in this case). As shown in Fig. 4, households that face lower incomes caused by a decline in wages will significantly reduce their consumption.

Figure 5 shows the decrease in recourse to foreign assets. This is explained by the LFI economy characterized by higher transaction costs than in an MFI economy. This discourages households from acquiring international funds, which in turn excludes the opportunity to smooth out their consumption following a shock, therefore, reinforcing the negative effect on consumption. In turn, domestic producers then reduce their production. Due to declining demand, there is no substitution effect, so companies reduce their demand for capital, labor, and oil. The reduced demand for the outputs of production depresses real wages and the capital interest rate, so investment decreases. This reduction also lowers the marginal cost of inputs, leading to deflation.[5] In an attempt to revive the economy, the central bank lowers its base interest rate. GDP also falls in the short term because of reduced domestic production. This resembles Kilian et al.'s (2009) finding, where the oil demand shocks affect U.S. GDP in the short term, as well as that of Vasconez et al. (2015). Similarly, a larger drop is seen in production following the shock than would be seen in an MFI economy. On the other hand, the appreciation in the nominal and real exchange rates is less important than it would be in an MFI economy, with a larger gap due to the great reaction in the inflation rate.

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[5] The IRFs of these macroeconomic variables are presented in the Online Supplemental Appendix.

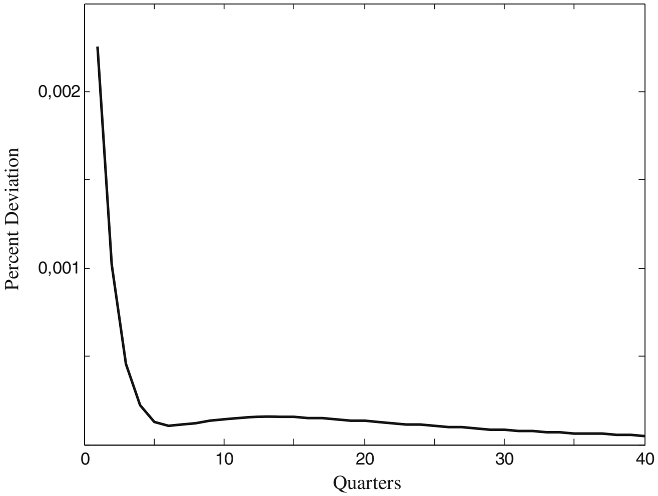

Fig. 2 Responses of GDP to one standard deviation shock on oil real price. Case MFI economy. Sources: Authors' own calculations based on model simulation

Sensitivity Analysis

Here, the oil price shock effect is analyzed following the substitution elasticity change between oil and domestic goods to see if it has a significant impact on macroeconomic variables. The Online Supplemental Appendix presents the IRFs of the different macroeconomic variables following an oil shock, when $\gamma = 0.11$ and $\gamma = 0.05$, in both MFI and LFI economies. Increasing the substitution elasticity between oil and domestic goods allows importing countries to reduce their oil dependency, leading to a decrease in the quantity of imported oil. More specifically, companies are requested to increase their use of domestic goods instead of oil. This mitigates the adverse effects of oil

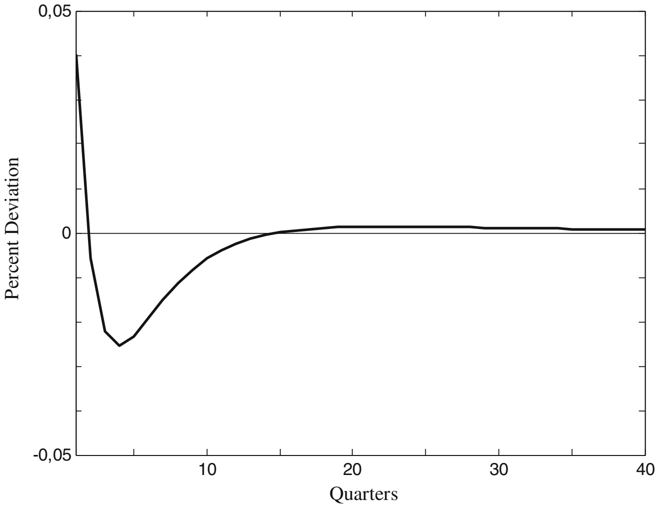

Fig. 3 Responses of investment to one standard deviation shock on oil real price. Case MFI economy. Sources: Authors' own calculations based on model simulation

shocks on consumption, production, and investment. This intuitive finding is confirmed in both IRFs, which show a clear effect on the predicted variables following a variation in the substitution elasticity γ. In this case, agents will resort to fewer foreign assets in the case of an MFI economy (Fig. 6). Therefore, when the effects in MFI and LFI economies were compared, there was a similar effect, as was discussed in the previous two subsections (i.e., agents in an LFI economy cannot buy foreign bonds in the presence of high transaction costs). Both figures also show a small change in inflation, so the interest rate does not need to react as much as it would have to in the case of high-substitution elasticity (i.e. when $\gamma = 0.11$).

Conclusion

The main objective of this paper is to study how international financial integration affects the behavior of macroeconomic variables when oil price shocks hit an economic system. The effects of oil shocks were examined through a New-Keynesian model in which the role that financial integration can play is verified in studying this effect on the economy.

The IRF generated by this model show that more financial integration tends to dampen the effect of increasing oil prices. In fact, in an MFI economy, agents will react greatly to foreign assets by providing them at a lower cost in order to smooth their consumption (risk sharing). This explains the slight effect on consumption, production, and investment in MFI economies. In an LFI economy, in contrast, companies cannot finance their investment by issuing foreign bonds because of fairly high transaction costs. This discourages firms from investing and reinforces the negative effect on income. Similarly, less financial integration reinforces the negative effect on consumption following an oil shock, because households do not have the opportunity to smooth out their consumption in the presence of significant adjustment costs. Thus, the analysis in this paper confirms some of conclusions of the Sutherland (1996) and

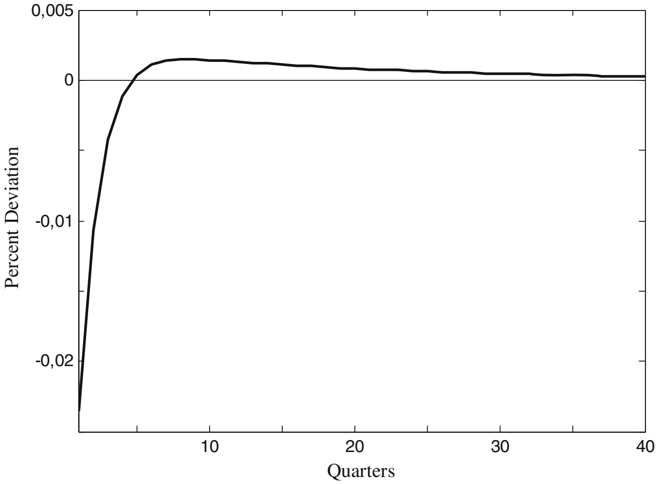

Fig. 4 Responses of consumption to one standard deviation shocks on oil real price. Case LFI economy. Sources: Authors'own calculations based on model simulation

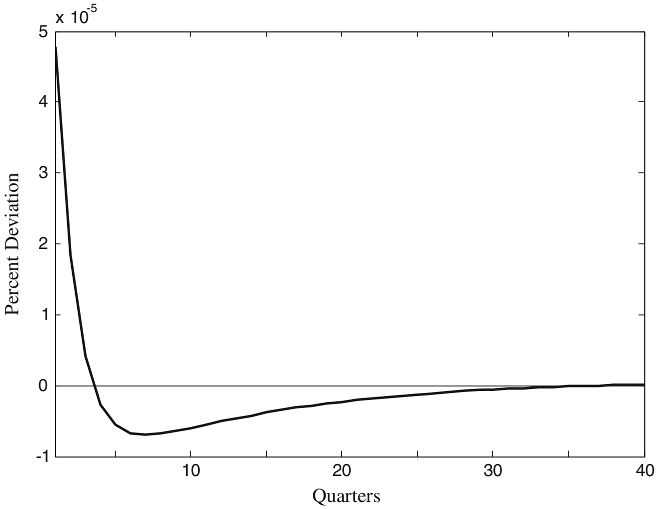

Fig. 5 Responses of foreign funds to one standard deviation shock on oil real price. Case LFI economy. Sources: Author's own calculations based on model simulation

Ghazouani et al. (2019) that the fluctuations to which the economy is exposed depend on both the degree of openness and the shocks that hit the system.

Our sensitivity analysis allowed us to conclude that the adverse effects of an oil price shock on consumption, production, and investment can be mitigated by a greater elasticity of substitution between oil and non-oil goods. Increasing the elasticity of substitution between oil and domestic goods allows importing countries to reduce their dependence on oil, leading to a decrease in the quantity of import oil. More specifically, companies are encouraged to increase their use of domestic goods instead of oil,

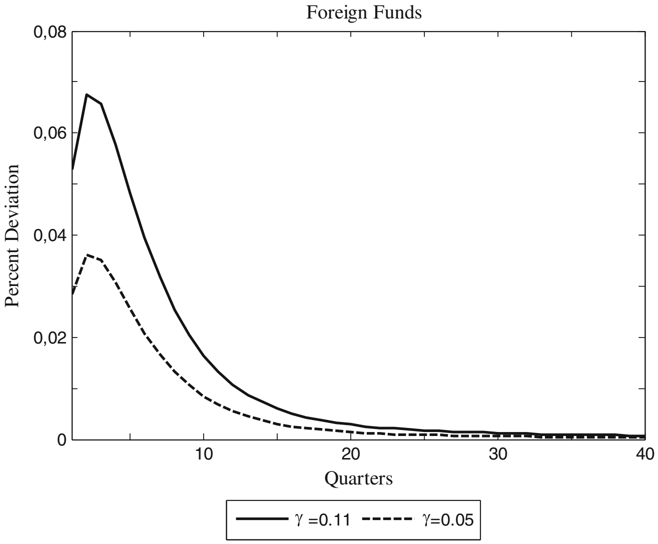

Fig. 6 Sensitivity analysis: Variation in the elasticity of substitution between non-oil goods and oil. Case MFI economy. Sources: Author's own calculations based on model simulation

because this has the effect of mitigating the harmful effects of an oil shock on the economy. Here again, financial integration plays an important role in reducing the oil shock effect, because agents in an MFI economy will resort to foreign assets at a lower cost, unlike agents in an LFI economy.

Finally, this paper considered a New Keynesian model in which the calibration was done according to Vasconez et al. (2015), where estimations and calibrations were done according to quarterly U.S. data. However, this approach provides less clear evidence regarding the distinction between a MFI economy and a LFI one. It would be a good idea to have two different sets of calibrations based on two separate countries, one that is MFI and the other that is LFI.

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