Oil markets and global economic conditions: Evidence from a general equilibrium model*

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Abstract

This paper develops a Real Business Cycle (RBC) model to shed light on the SVAR literature debate about the sources of fluctuation in world oil prices. This debate centers on different assumptions on the short-run price elasticity of oil supply in SVAR models. Our RBC model defines the short- and long-run elasticities, as well as the adjustment speed of oil supply, as a function of a few structural parameters within the model. We show that the long-term elasticity and the adjustment speed significantly alter the transmission of structural shocks to oil prices, while the short-run elasticity alone does not. We estimate the model with Bayesian methods using monthly data from 1975-2019. The results show that incorporating prior knowledge of the long-run elasticity and adjustment speed of oil supply plays a key role in estimating the relative importance of supply and demand shocks in driving oil prices. In our conservative estimate, oil supply shocks account for about 16% of the variation in oil prices. This value falls to 7% when we assume uninformative prior on the long-run elasticity.

JEL classifications: E3, E43, E52, C51, C33

Keywords: Oil market, RBC, Bayesian estimation, supply elasticities.

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1 Introduction

What are the causes and consequences of oil price fluctuations? This question is of central importance to academics, practitioners, and policymakers alike. From the oil shocks of the 1970s to the commodity boom of the 2000s, oil prices showed large fluctuations, with important implications for firms, households, and governments in both importing and exporting countries.

A large body of literature has used structural vector autoregressive (SVAR) models to identify the sources of oil price fluctuations, but there remains a debate about the relative contributions of demand and supply shocks. For instance, Kilian (2009) (hereafter K09) and Kilian and Murphy (2012, 2014) (KM12 and KM14) attribute most oil price fluctuations to demand shocks, while oil supply shocks account for less than 10% of the forecast error variance decomposition (FEVD).[1] On the contrary, Baumeister and Hamilton (2019) (BH19) and Caldara et al. (2019) (CCI19) argue that oil supply shocks play a more important role, contributing up to 37% of the FEVD. The debate centers on different assumptions on the short-run price elasticity of oil supply used in SVAR models (Herrera and Rangaraju, 2020). K09, KM12, and KM14 assume that this elasticity is very small, in the range of 0 to 0.026, whereas CCI19 and BH19 argue for a larger value around 0.08-0.10.

None of these studies incorporate prior knowledge about the adjustment speed and long-run elasticity of oil supply, although prior knowledge about these parameters is also available in the literature that studied oil production.[2] In fact, the SVAR literature has mostly focused on the one-month elasticity due to the difficulty of introducing prior knowledge about this elasticity at longer horizons. While it is not possible to perfectly measure these elasticities at longer horizons with SVAR models, a careful inspection of the impulse response functions (IRFs) of KM12 and BH19 indicates that the difference in the price elasticity of oil supply may not be limited to the short run. We conjecture that this difference also contributes to the contrasting results obtained in their studies.

In this paper, we propose a new Real Business Cycle (RBC) model that defines the short- and long-run elasticities, as well as the adjustment speed of supply, to shed light on the debate regarding the sources of oil price fluctuations. These elasticities and the adjustment speed are expressed as functions of a few structural parameters, allowing us to exploit all

[1] Their findings were later confirmed by subsequent studies, see for e.g., Juvenal and Petrella (2015); Antolín-Díaz and Rubio-Ramírez (2018); Zhou (2020); Cross et al. (2022); Braun (2023).

[2] Our review of the literature indicates a mean value of 0.45 for the long-run elasticity (e.g., Bornstein et al., 2023; Bogmans et al., 2024; Golombek et al., 2018; Rao, 2018), and studies of the physical constraints in oil production – suggesting half-life's of about two years for conventional wells – can be used to infer the adjustment speed (Kellogg, 2014; Wachtmeister et al., 2017; Anderson et al., 2018; Newell and Prest, 2019).

the available prior knowledge about the dynamic response of oil supply at different horizons. Our framework offers a clear advantage over SVAR models, which so far have focused only on the short-run elasticity. Our RBC model is also flexible enough to vary the one-month elasticity without altering its value at any other horizon, allowing us to disentangle the direct and indirect effects of the one-month elasticity on oil price dynamics.

Our RBC model builds on the state-of-the-art SVAR models of KM14 and BH19, allowing us to compare our results with these benchmarks. It captures the dynamic behavior of endogenous global oil supply and demand, includes the same set of structural shocks, and is estimated on a comparable dataset. Specifically, we develop a two-good general equilibrium model with oil and final goods. Oil production combines three *factors* as follows: exploration yields exogenous discoveries of exploitable *land* on which *capital* investment is required to drill new wells operated with *labor*. This combination generates short- and long-run price elasticities of oil supply that are functions of the factor shares and of their degree of substitutability. Moreover, we assume that investment in new oil wells is irreversible and that production declines gradually over time – facts that are well known in the oil industry – so that a decay parameter governs the adjustment speed of oil supply to its long-run equilibrium. From the demand side, oil is consumed as an input in the production of the final good and held as inventories by competitive storage firms.

Our theoretical results show that varying the one-month elasticity of oil supply, while holding all other parameters of our model unchanged, has a limited direct effect on the dynamics of oil prices. For instance, imposing a perfectly inelastic oil supply in the short run amplifies the effect of a global economic activity shock on oil prices. However, this amplification is limited to the short run and mitigated by the response of inventories demand, which partially offsets the short delay in the response of supply. In contrast, varying the adjustment speed and the long-run elasticity of supply have a stronger impact on oil prices at all horizons.

These theoretical predictions of our RBC model suggest that a root cause of the disagreement in the SVAR literature on the sources of oil price fluctuations may stem from differences in the adjustment speed and the long-run elasticity of supply. Therefore, more attention should be paid to the elasticity of oil supply at different horizons to understand the drivers of oil prices with SVAR models. In fact, our empirical analysis, discussed bellow, also reveals that restrictions imposed on this elasticity in the short run can also affect its estimated value in the medium and long run, helping to explain why seemingly small changes in the one-month elasticity lead to radically different conclusions regarding the sources of oil price fluctuations.

We estimate the model with Bayesian methods using monthly data from 1975-2019. Two main additional results stand out. First, we show that incorporating prior knowledge about the adjustment speed and the long-run elasticity of oil supply has important implications for the relative contribution of supply and demand shocks to oil prices. With uninformative priors for these parameters, we obtain posterior modes of the adjustment speed and the long-run elasticity of oil supply that are either too slow or too small, leading us to underestimate the importance of supply shocks for oil prices. This result is robust to the use of different priors inspired by KM12 and KM14 or CCI19 and BH19 for the short-run elasticity.

For instance, with an uninformative prior on the long-run elasticity and a short-run elasticity in the range of 0 to 0.026, our estimated long-run elasticity is also low, around 0.05. As a result, supply shocks account for only 7% of the variation in oil prices, in line with the results of KM12 and KM14. However, a value of 0.05 for the long-run elasticity falls outside the range of available estimates in the literature. With an informative prior supported by the literature, the posterior mode for the long-run elasticity increases from 0.05 to 0.26 and the median contribution of supply shocks to oil prices increases from 7% to 16%. This is a substantial increase in the contribution of supply shocks especially given that the short-run elasticity has an upper bound of 0.026. Imposing a long-run elasticity of 0.45 (corresponding to the average estimate in the literature) further increases the contribution of supply shocks to 22%. On the other hand, we also experiment with different prior for the short-run elasticity of oil supply from CCI19, which has a mean of 0.08 and standard deviation of 0.04. This prior is also consistent with BH19. We find that incorporating prior knowledge of the long-run price elasticity (LRPE) of oil supply also matters in this case. With a relatively flat prior, the mode of LRPE stands at 0.09, with oil supply shocks contributing 17% to oil prices variation. Assuming an informative increases the mode to 0.31 and raises the contribution of supply shocks from 17 to 36%.

Second, our empirical results indicate that oil demand shocks are the most important drivers of oil prices, but also show that supply shocks do matter. Global economic activity and oil-specific consumption demand shocks explain most of the variance in oil prices over the 1975-2019 period. We attribute the oil price boom in the early 2000s to the cumulative effect of aggregate demand shock, confirming the results of K09, KM12 and KM14. Nevertheless, we also find that oil supply shocks play a non-negligible role. For example, our historical decomposition reveals that weaker-than-expected supply conditions contributed to keeping oil prices high in the early 1980s and after the global financial crisis.

In addition to addressing the SVAR debate about the sources of variation in oil prices, our paper makes other significant contributions to the literature. Our model combines sev-

eral identifying restrictions popular in SVAR studies and additionally allows to use prior knowledge about the adjustment speed and the long-run elasticity of supply.[3] This tool can be applied to many different commodities where supply is slow to adjust. In the future, larger shocks to commodity demand can be expected as the world transitions to a greener economy. In the case of a sustained shift in commodity demand, the long-run elasticity of supply plays a crucial role.

Finally, our paper relates to a growing literature that endogenizes the price of commodities in DSGE models (e.g., Balke et al., 2010; Nakov and Pescatori, 2010; Bodenstein et al., 2011; Unalmis et al., 2012; Peersman and Stevens, 2013; Bergholt et al., 2019; Houssa et al., 2023). Our main contribution to that literature is that we analytically derive the price elasticities of commodity supply and demand to introduce priors. Moreover, DSGE models traditionally use standard CES production or utility functions that impose a value of one on the income elasticity of oil demand, while we relax this assumption. Our empirical analysis supports an income elasticity greater than one. Thus, imposing a value of one would have led us to underestimate the contribution of global economic activity shocks to world oil prices.

The remainder of the paper is structured as followed. Section 2 motivates our analysis. In Section 3, we present our RBC model of the global oil market. Section 4 illustrates the crucial role that the elasticities and adjustment speed of supply play in the transmission of demand and supply shocks to oil prices. Section 5 quantifies the sources of oil price fluctuations. The last section concludes.

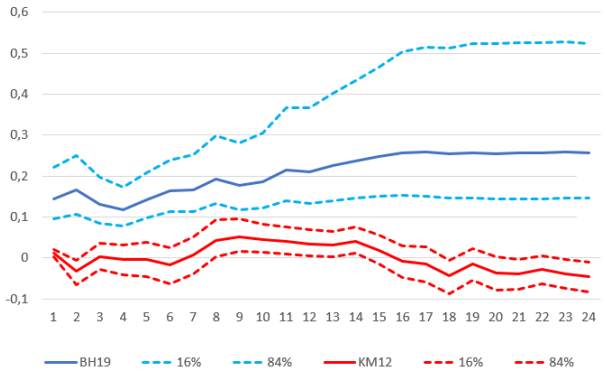
2 Motivation: supply elasticities in SVAR studies

We compare the price elasticity of oil supply at different horizons (ranging from one to 24 months) reported in KM12 and BH19. We compute these elasticities based on the ratio of the IRFs of oil production and oil prices following an aggregate demand shock (left panel) and an oil-specific demand shock (right panel), which provides an approximation to the true elasticities (one can only recover the true value of this elasticity at the one-month horizon in BH19). It shows that the one-month price elasticities of oil supply strongly differ between KM12 and BH19, due to the different bands or priors imposed in these studies.

What stands out is that the disagreement on the one-month price elasticity of oil supply persists in the medium run. In KM12, the price elasticity of oil supply is bounded in the range

[3] KM12 proposed the idea of combining different types of identifying restrictions (sign and magnitude restrictions) in a SVAR framework, and BH19 described how one can introduce prior knowledge on a contemporaneous elasticity. Sign restrictions are discussed in Lippi and Nobili (2012); Baumeister et al. (2010); Baumeister and Peersman (2013b,a); Peersman and van Robays (2009); Lütkepohl and Netšunajev (2014).

Figure 1: Approximated supply elasticities at different horizons:
BH19 (blue) vs KM12 (red)



Note: We use aggregate demand shocks to approximate these elasticities. Results are similar with oil-specific demand shocks. We are grateful to BH19 for sharing their codes allowing us to reproduce their results and those of KM12 [with extended sample?]

of 0 to 0.026 on impact and then becomes statistically not different from zero. In contrast, the estimated elasticities of BH19 remain greater than zero. In both cases, the median estimates are rather flat, which may indicate that imposing a certain value on impact (via magnitude restrictions in KM12 or using a prior in BH19) also affects this elasticity in the medium run.

These estimated elasticities also violate reasonable restrictions that one may want to impose on the medium-run price elasticity of oil supply. First, some draws appear to support a negative elasticity, implying that oil production falls in response to higher oil prices. Second, it is not always clear whether the medium-run elasticity is larger than the short-run elasticity. However, one may want to impose that the elasticity of oil supply cannot become negative, and that the medium-run elasticity cannot be smaller than the short-run elasticity.

It is important to note that these elasticities are only approximations. For example, a favorable aggregate demand shock could raise both the price of oil and the cost of inputs used in the oil extraction process, leading to a decline in oil production even with a positive price elasticity. The implication is that while the frontier SVAR models of KM12 and BH19 could violate reasonable restrictions on the medium- or long-run elasticities of oil supply, imposing such restrictions would not be straightforward. BH19 showed how to impose a prior on the one-month elasticity, but extending this strategy to the medium or long-run elasticities is not easy in an SVAR environment.

We thus propose to build an RBC model in which the short and long-run elasticities of oil supply can be expressed as a simple function of a few structural parameters. This strategy

Table 1: Long-run elasticities of oil supply

	One year	Long-run	Description
Greene and Leiby (2006)		0.20-0.66	Literature review (6 estimates)
Fally and Sayre (2018)		0.29-0.60	Literature review (3 estimates)
Rao (2018)		0.38	After-tax price elasticity, California, 1980s.
Golombek et al. (2018)		0.32	Dominant firm model, non-OPEC producers, 1986-2009
Bogmans et al. (2024)	0.13	0.46	IV = country specific shocks, world, 1960-2024
Bornstein et al. (2023)	0.19		IV = global business cycle, world, 1971-2015
Average		0.45	
standard error		0.13	

The mean and standard error are computed using all individual estimates in the literature reviews, such that all 12 estimates have the same weight.

has two advantages. First, the structural equations of the models imply that the long-run elasticity of oil supply must be greater than or equal to that in the short run (for reasonable values of these structural parameters). Second, one can directly estimate and impose priors on both the short and long-run elasticities and recover the value of the structural parameters as byproducts. This model is described in the next section.

3 RBC model with oil

We extend a standard RBC model (e.g., King and Rebelo, 2000; Francis and Ramey, 2005) featuring external habits in consumption (Abel, 1990), and investment adjustment costs (Christiano et al., 2005) with oil used as inputs in the production of final goods and held as inventories by competitive storage firms. We begin by examining the optimization problem of oil producers, focusing on its implications for both short- and long-run elasticities and the speed at which supply adjusts. Next, we analyze the final good producers, delving into the price and income elasticities of oil demand. We then describe the demand for inventories by competitive storage firms and provide a brief overview of the standard optimization problem for households, who supply labor and capital to final good producers. Finally, we present our estimation method and priors for the oil elasticities, and we compare the restrictions implied by our model with those in the SVAR literature. In appendix A, we show how we obtain all our elasticities. Appendix B details the the optimization problem of household and the calibration or estimation of the parameters that are standard in the RBC literature.

3.1 Oil supply

Oil is produced in three stages that capture the most relevant features of the oil extraction industry. First, the exploration and permitting stage generates discoveries of new exploitable land ($L_t(o)$) in every period. We assume that this process is exogenous, capturing the length, complexity, and uncertainty associated with it.

Second, new wells ($\Lambda_t^{new}(o)$) are drilled on the land using investment in physical capital:

$$\Lambda_t^{new}(o) = A_o \left[(1-\gamma_o)^{\frac{1}{\theta_o}} I_t(o)^{\frac{\theta_o - 1}{\theta_o}} + (\gamma_o)^{\frac{1}{\theta_o}} L_t(o)^{\frac{\theta_o - 1}{\theta_o}} \right]^{\frac{\theta_o}{\theta_o - 1}}, \tag{1}$$

where θ_o is the elasticity of substitution between capital and land in the production of new wells and γ_o is the income share of land. The parameter A_o is a scaling constant. These new wells are added to the existing stock of wells after a one period lag (the drilling stage usually takes 50 to 60 days on suitable locations where permits have already been obtained). This one period lag ensures that a change in drilling activity cannot affect oil supply within a month and does not affect the short-run elasticity (more details shortly). The total stock of well available for production is thus given by

$$\Lambda_t(o) = (1-\delta)\Lambda_{t-1}(o) + \Lambda_{t-1}^{new}(o) \tag{2}$$

where existing wells depreciate at a rate δ. This depreciation rate captures the fact that investment in oil wells is irreversible and that the oil flow from a well slowly declines over time. The half-life of a well - which is defined as the point in time after which half of the total stock of oil has been retrieved - is given by $\frac{1-\delta}{\delta}$. When estimating the model, we will draw on various studies of oil well production to build a prior for this parameter, which will play a crucial role as it governs the adjustment speed of oil supply toward its long-run equilibrium. Already note that the adjustment speed increases in the δ, because a lower life of existing wells means that the effect of past investment decisions on the current stock of exploitable wells quickly decays (more details in section 3.7).

In the third stage, oil is produced by operating wells with labor

$$Y_t(o) = \varepsilon_t^{os} \left[(1-\alpha_o)^{\frac{1}{\Theta_o}} H_t(o)^{\frac{\Theta_o - 1}{\Theta_o}} + (\alpha_o)^{\frac{1}{\Theta_o}} \Lambda_t(o)^{\frac{\Theta_o - 1}{\Theta_o}} \right]^{\frac{\Theta_o}{\Theta_o - 1}} \tag{3}$$

where Θ_o is the elasticity of substitution between labor and wells in oil production, $1-\alpha_o$ is the labor share, and ε_t^{os} is an oil-supply shock. Labor is the only adjustment margin in the short-run in our model. It captures the idea that - to some extent - production can be

adjusted in the short-run.[4]

To obtain an analytical expression of the short-run elasticity of oil supply, we first derive the the first order condition to the oil producer's problem knowing that there is a one period lag between investment and the start of production in a new well. We then evaluate how supply responds to a change in oil prices. The short-run elasticity derived from the immediate oil supply response to a shift in prices is given by:

$$\sigma_{\text{SR}} = \frac{\Theta_o(1-\alpha_o)}{\alpha_o}. \tag{4}$$

The short run elasticity increases with the elasticity of substitution between labor and wells Θ_o and with the labor share $(1-\alpha_o)$. In the short run, the only adjustment margin is labor, because it takes time to drill a new well. Intuitively, the parameter Θ_o captures the technical feasibility of raising production with more labor. For given (or observed) labor share, one can thus set Θ_o to reach any short-run price elasticity of oil supply (this elasticity will be estimated). In the limit case where the elasticity of substitution Θ_o is calibrated to zero, supply becomes perfectly inelastic in the short-run, as it is not possible substitute wells with labor - the only variable production factor in the short run - to adjust production. To implement the restriction of K09, one can thus set $\Theta_o = 0$. To implement the prior of BH19, one would opt for small but positive Θ_o.

To find a closed-form solution for the long-run elasticity of oil supply, we evaluate how oil supply adjust to a permanent increase in oil prices. In the long-run, both labor and the number of new wells become variable production factors. The long-run oil supply response to a permanent shift in prices is given by:

$$\sigma_{\text{LR}} \quad = \quad \sigma_{\text{SR}} + \frac{\theta_o(1-\gamma_o)}{\alpha_o\gamma_o} \tag{5}$$

The long-run elasticity is bounded from below at the level of the short-run elasticity, because labor is an adjustment margin that is available both in the short and long-run. Moreover, it increases with the elasticity of substitution between land and capital investment θ_o and with the capital share $(1-\gamma_o)$, as capital investment can be adjusted in the long-run (while the stock of land cannot). It is also interesting to note that without land, this elasticity would

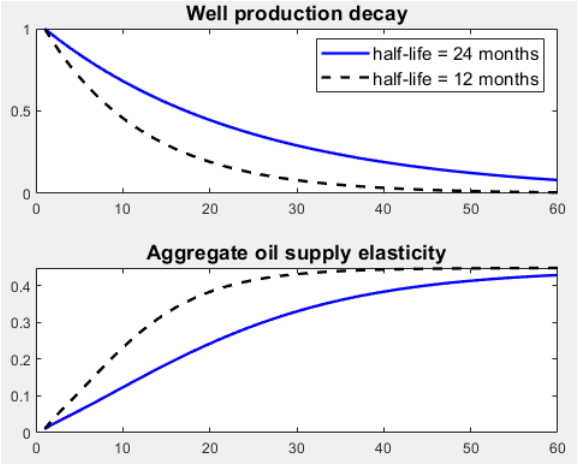
[4] An interpretation is that producers can decide to postpone the planned closure of low productivity (or almost depleted) wells in response to higher than anticipated prices by hiring more labor. One can also interpret the labor input more brodely to include all variable production factors, including the energy used to insert water or gas to keep the pressure (and thus to maintain production) in old wells that might otherwise be closed.

be infinite. Its importance in the production of oil and the exogeneity assumption of the exploration and permitting stage are thus crucial to control the value of this elasticity. To study the dynamics of oil prices at business cycle frequencies, this assumption is reasonable, as this stage often takes years or even decades before production can effectively start.

A first advantage of our simple model is thus that we can easily estimate and/or introduce prior knowledge on the short and long-run elasticities of oil supply. When we estimate the model, we estimate σ_{SR} and σ_{LR} directly and we calibrate the factor shares to the data. This allows us to easily recovers the structural parameters of our model (θ_o and Θ_o) as by-products. The only constraint is that the medium-run elasticity cannot be lower than the short-run elasticity, which is supported by the empirical evidence described in section 3.7.

A second advantage is that a single parameter – the well-decay rate (δ) – governs the speed of adjustment of oil supply from the short to the long-run elasticity. The fact that oil wells production slowly decays over time ensures that the effect of past drilling investment decisions persist over time and that the response of oil supply to an unexpected change in prices is gradual.

Figure 2: Adjustment speed towards the long-run elasticity



The effect of the well decay rate on the adjustment speed of oil supply is best illustrated on Figure 2. The upper panel shows two different production patterns for oil wells, with half-life calibrated to one ($\delta = 0.08$) and two years ($\delta = 0.04$), respectively. The lower panel contrasts the difference in aggregate oil supply elasticities at different horizons. While changes in the delta do not affect the values of the short and long-run elasticities (calibrated to 0.01 and 0.45 in our baseline, see section 3.7), a larger decay rate is associated with a faster adjustment speed towards the long-run elasticity.

3.2 Oil consumption demand

Oil is consumed by final good producers who combine labor, capital, and oil inputs to produce their goods ($Y_t(f)$) that are sold as consumption or investment goods. They operate in a perfectly competitive environment and maximize their profits given by

$$Y_t(f) - w_t H_t(f) - r_t^k(f) K_t(f) - p_t(o) O_t(f),$$

where $p_t(o)$ is the real price of oil and the final good is used as a numeraire to express all prices in real terms.

Production consists of two steps. First, firms combine labor and capital - their value added denoted VA - using a standard Cobb-Douglas technology:

$$VA_t(f) = \varepsilon_t(f) K_t(f)^{\alpha} H_t(f)^{1-\alpha}, \tag{6}$$

where $\varepsilon_t(f)$ is productivity shock capturing exogenous shifts in global economic activity. Second, they combine their value added with oil using a modified CES production function to produce final goods:

$$Y_t(f) = Y(f) \left[(1-\omega_o)^{\frac{1}{\eta_o}} \left(VA_t(f)\right)^{\frac{\eta_o - 1}{\eta_o}} + (\omega_o)^{\frac{1}{\eta_o}} \left(\varepsilon_t^{od}(O_t(f) - \bar{O})\right)^{\frac{\eta_o - 1}{\eta_o}} \right]^{\frac{\eta_o}{\eta_o - 1}}, \tag{7}$$

where the parameter η_o controls the oil demand elasticity of substitution and ω_o is the oil share in production. The parameter $\bar{O}$ controls the output elasticity of oil demand. When $\bar{O}$ is set to zero, we are back to a standard CES production with an output elasticity of oil demand equal to one.

The first order condition (w.r.t. oil) of the final good producer's problem yields the following linearized oil demand curve:

$$\hat{O}_t(f) = \chi_{\text{Y}} \hat{Y}_t(f) - \chi_{\text{P}} \hat{p}_t(o) - \hat{\tilde{\varepsilon}}_t^{od}, \tag{8}$$

where $\chi_{\text{Y}} = \frac{O(f) - \bar{O}}{O(f)}$ is the output elasticity of oil demand and $\chi_{\text{P}} = \eta_o \frac{O(f) - \bar{O}}{O(f)}$ is the price elasticity of oil demand.

When we estimate the model, we estimate χ_{Y} and χ_{P} directly. This allows us to easily recovers the structural parameters of our model with $\bar{O} = (1 - \chi_{\text{Y}}) O(f)$ and $\eta_o = \frac{\chi_{\text{P}}}{\chi_{\text{Y}}}$.

3.3 Storage and oil-inventory demand

Storage is competitive (e.g., Wright and Williams, 1984; Deaton and Laroque, 1992) and brings a convenience yield (e.g., Williams, 1987; Pindyck, 1994; Alquist and Kilian, 2010). Competitive risk-neutral storage firms maximize their expected profits of holding oil inventories $V_t(o)$:

$$\varepsilon_t^v(o)p_{t+1}(o)V_t(o) - p_t(o)V_t(o)\Phi(V_t(o)), \tag{9}$$

where ε_t^v is a storage-demand shock, $p_{t+1}(o)$ is the expected future price of oil, and $\Phi(V_t(o)) = \beta\left(V_t(o)/V(o)\right)^{1/\varphi(o)}$ captures a storage cost net of a convenience yield that depends on the total level of oil inventories.[5] Under these assumptions, the linearized FOC of the storage firm is:

$$\hat{V}_t(o) = \varphi(o)\Big\{\hat{p}_{t+1}(o) - \hat{p}_t(o) - \hat{\varepsilon}_t^v\Big\}. \tag{10}$$

The implication is that storage demand depends positively on the expected price gains of holding oil inventories and on a shock that captures speculation/precaution motives. The parameter $\varphi(o)$ is the storage demand elasticity to the expected change in oil price.

3.4 Households

Households derive utility from consumption and dis-utility from labor in the final good sector. They maximize their utility given by

$$\mathrm{E}_0^j \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_{j,t} - \mathbf{b}C_{t-1})^{1-\sigma_c}}{1-\sigma_c} - A_h \frac{(H(f)_{j,t})^{1+\sigma_h}}{1+\sigma_h} \right], \tag{11}$$

where $\mathbf{b}$ is an external habit parameter, under their budget constraint

$$C_t + I_t(f) + B_{t+1} = R_{t-1}B_t + w_t H_t(f) + r_t^k(f)K_t(f) + \Pi_t(o) \tag{12}$$

[5] It is commonly assumed that the marginal convenience yields declines with the total stock of inventories and that the marginal storage cost is constant. In this case, the marginal net storage costs is increasing in the total stock of inventories, and this is captured by our net cost function $\Phi(V_t(o))$.

where R_t is the real gross rate of interest paid on bonds B_t. The term $\Pi_t(o)$ represents profits transferred from oil producers. The capital accumulation rule is

$$K_{t+1}(f) = \left[1 - \frac{\phi(f)}{2}\left(\frac{I_t(f)}{I_{t-1}(f)} - 1\right)^2\right] I_t(f) + (1-\Delta)K_t(f), \tag{13}$$

where $\phi(f)$ is the investment adjustment cost in the final good sector and Δ is the depreciation rate of capital.

3.5 Market clearing

The oil market clears when the gap between demand and supply matches the change in inventories: $V_t(o) - V_{t-1}(o) = Y_t(o) - O_t(f)$. The final good market clears when production equals the demand of households for consumption and investment goods: $Y_t(f) = C_t + I_t(o) + I_t(f)$. Appendix B describes the households' consumption and investment demand.

3.6 Bayesian estimation method and the data

We estimate our model with Bayesian methods (e.g., DeJong et al., 2000; Otrok, 2001; Schorfheide, 2000) in Dynare (Adjemian et al., 2011). We focus on a period ranging from 1975M1 to 2019M12. The choice of our starting date is guided by the fact that K09, KM12, KM14 and BH19 use a sample of monthly data starting in 1973 to estimate SVAR with 24 lag. The end date excludes the pandemic period. We experimented starting after the Great Moderation (as CCI19) and in 1995 after oil supply became less volatile to to account for the potential presence of time-variation in our estimated parameters and to evaluate the drivers of oil prices in the most recent period.[6]

Our data set includes four variables: the prices, inventories, and production levels of oil, and a world industrial production index. We follow the SVAR literature and use the monthly growth rate of these variables. The price of oil comes from the world bank pink sheet. We

[6] Our starting date excludes the 1973/74 oil crisis. As argued by Baumeister and Kilian (2016), there are two conflicting views regarding the drivers of the oil price increase in that period. The conventional view relies on an oil supply cut in response to the war between Israel and a coalition of Arab countries. But another likely explanation for the rise in oil price is an endogenous adjustment to a strong demand for oil combined to a devaluation of the dollar. At that time, the price of oil produced by Middle Eastern countries had been fixed for a duration of five years. It is thus possible that the increase in oil prices were the reflection of demand/supply imbalances that predated the war. Exploring this question would however best be answered with a model capturing a structural break in the pricing of oil. By applying our simple model to this period, we might wrongly fully associate the oil price increase in 73/74 to an oil supply shock, because our model does not account for fixed prices. Avoiding this issue is an extra motivation for starting our estimation in 1975.

compute real oil prices by dividing the nominal prices by the US CPI. Crude oil production at the world level directly comes from the EIA. Following Kilian and Murphy (2014), we use total US crude oil inventories scaled by the ratio of OECD petroleum stocks over US petroleum stocks. Data are from the EIA and this strategy is followed because crude oil inventories are not available at the world level. The world industrial production index is borrowed from Baumeister et al. (2022).

In a robustness exercise, we also use the first principal component extracted from the prices of a set of non-energy industrial commodities following Alquist et al. (2019). As argued by Kilian and Zhou (2018), this measure can capture anticipations about the future level of economic activity. The price of industrial commodities also has the advantage of being easily introduced in our model (by adding a second commodity used to produce final goods).

3.7 Prior's distributions

The estimation of the short-run elasticity of oil supply has been the subject of large body of literature including the contributions and reviews of the literature of CC19, BH19 and Kilian (2022). While the exact value of this elasticity is debated, it is likely to be very low. On the one hand, KM12 and KM14 introduce a bound of 0.026, that we will use as our first benchmark case. On the other hand, CCI19 estimate its value to 0.08 with a standard error of 0.04. Their estimated mean is also close to the average value reported in their search of the literature (equal to 0.1). The mode of BH's prior is also similar and set to 0.1. For this reason, we will use the CCI19 estimated mean and standard error as a second benchmark case.

For the prior of the long-run elasticity of oil supply, we set a mean of 0.45 and standard error of 0.13 based on the literature reviews of Greene and Leiby (2006); Fally and Sayre (2018) and on the recent studies of Rao (2018); Golombek et al. (2018); Bornstein et al. (2023); Bogmans et al. (2024). The price elasticity of oil supply is thus likely larger in the long run than in the short run. To evaluate the effect of introducing an informative prior on this elasticity, we will compare our results with those obtained using a less informative prior (we multiply the standard error of the prior by 3, resulting in a relatively flat prior).

While there exist a few studies of the oil markets that evaluates the short and long-run elasticities of oil supply, much less is known about the speed at which supply adjust to a persistent rise in prices. In our model, the supply elasticity transitions smoothly from its short to long-run value, and its speed is governed by the oil well depreciation rate. Oil production from existing wells is constrained by reservoir pressure, which decays as oil is

Table 2: Sign restrictions in KM14 and BH19

	Oil supply	Global activity	Oil-consumption	Oil-inventory
Oil production	-/-	+/+	+	+/+
Industrial prod	-/-	+/+	-	-/-
Oil price	+/+	+/+	+	+/+
Inventories				+/+

Sign restrictions imposed a priori in KM14 (black) and checked a posteriori in BH19 (blue). In BH19, their priors already imply a high probability that these restrictions are satisfied.

extracted (Kellogg, 2014; Wachtmeister et al., 2017; Anderson et al., 2018; Newell and Prest, 2019). The empirical evidence points at oil wells half-life shorter than 24 months, and we define our prior of δ to fit this value. This prior is also consistent with the one-year elasticities of Bornstein et al. (2023) and Bogmans et al. (2024).

We set the prior mean of our price elasticity of demand to 0.20 corresponding to the average of the values reported in the search of the literature of CCI19. This value is also close to the values implied by the recent, state-of-the art studies of Gasoline demand reported in Kilian (2022) and to the average estimate reported in the literature review of Hamilton (2009a). The estimated elasticities of CCI, KM14, and BH19 are 0.08, 0.26, and 0.35, respectively.

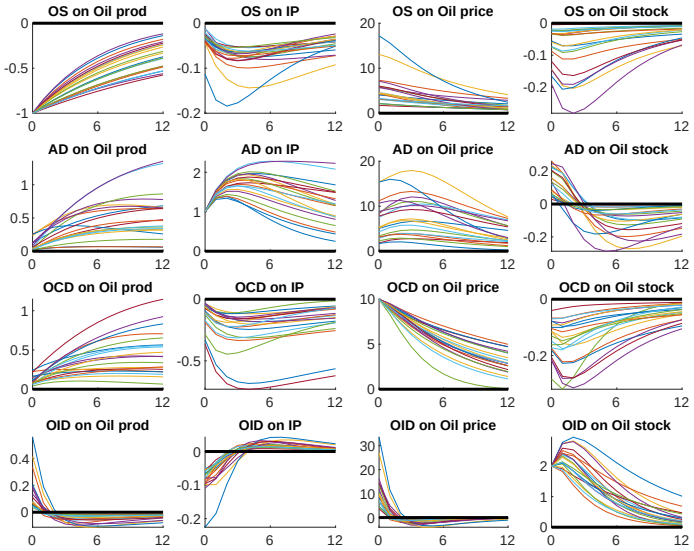
For the prior mean of the output elasticity of oil demand, we chose a value of one, which is the implicit assumption imposed by the literature that uses standard CES production or utility functions. This value stands within the bond of the values reported in the literature (Hamilton, 2009b; Havranek and Kokes, 2015; Golombek et al., 2018; Chang et al., 2019). A value of one tends to be supported by studies that do not control for the stock of car and thus capture a total long-run elasticity. We, however, allow for a relatively wide prior to account for the dispersion in the results obtained in the literature. We discuss the remaining parameters in appendix B.2.

3.8 Restrictions implied by our model and priors

We now discuss the sign and magnitude restrictions implied by our modelling, calibration, and prior. For this purpose, we generate the set of admissible IRFs based on 20 random draws from our priors (results are similar with a larger number of draws). The results are displayed in Figure 3. We consider that a sign restriction is imposed a prior when all draws are of the same sign.

Figure 3: Set of admissible IRFs

Note: Variables expressed in percentage deviation from steady state. Horizon in quarters. All lines correspond to a particular draw from our priors. The prior for the short-run elasticity of supply follows KM (we reach a similar conclusion with the prior of CCI19). 20 draws in total.



We compare our restrictions with popular sign restrictions used in the SVAR literature summarized in Table 2. Our restrictions are consistent with the sign restrictions of KM14 and BH19, which have been widely used in the SVAR literature (e.g., Lippi and Nobili, 2012; Baumeister et al., 2010; Baumeister and Peersman, 2013b,a; Peersman and van Robays, 2009; Lütkepohl and Netšunajev, 2014). Moreover, the impact of oil-specific consumption (and inventory) demand shock on global industrial production is quite small, which echoes the magnitude restriction of KM12. Thus, our model combines different identifying restrictions used in the SVAR literature with prior studies of the oil market in a statistically and structurally coherent framework.

4 Oil elasticities and the transmission of structural shocks

Since the seminal contribution of K09, a large literature has investigated the sources of variation in world oil prices. Within this SVAR literature, there is disagreement about the relative importance of demand and supply shocks for oil prices: models that allow for a larger elasticity of oil supply in the short run are associated with a larger relative contribution of oil supply shocks to oil prices (and vice versa). We use our model to show that varying the one-month elasticity of oil supply (from 0 to 0.15), while holding all other parameters of

our model unchanged, has a limited direct effect on the dynamics of oil prices (Section 4.1). Thus, the reason why different values of this one-month elasticity lead to radically different oil price dynamics, as reported in the SVAR literature, is far from obvious.

We conjecture that imposing a lower short-run price elasticity of oil supply affects the estimates of the other elasticities in the model. We show that a joint shift in the short and long-run elasticities of oil supply has the potential to explain the disagreement in the SVAR literature (section 4.2). Moreover, we show that changes in the adjustment speed and long-run price elasticity of oil supply (sections 4.3 and 4.4) and in the price and income elasticities of oil demand (in appendix C.1) can substantially alter the dynamic response of oil prices to structural shocks. A conclusion of our exercise is that the debate, which initially focused on the short-run price elasticity of oil supply, and later included the price elasticity of demand, should be broadened to include the medium and long-run elasticities of oil supply.

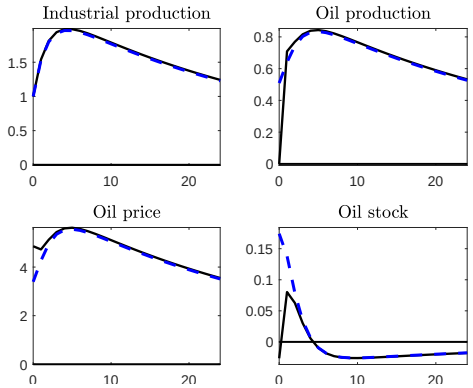
4.1 The one-month price elasticities of oil supply

A difference in the one-month elasticity of oil supply alone is unlikely to explain the very different responses of oil prices to a global activity shock found in the SVAR literature. To illustrate this point, we simulate the effect of a global activity shock in two economies. In the first economy, we use a value of 0.15 for both the short and long-run elasticities of oil supply. These values are consistent with those obtained by BH19, so we refer to this economy as the BH19-inspired calibration. The other parameters are calibrated to our priors. In the second, we set the one-month price elasticity of oil supply to zero while leaving all other parameters unchanged.

We implement this zero-restriction on the one-month elasticity by assuming that hours worked in the oil sector are fixed one month in advance. This assumption only restricts the response of oil supply on impact. Simply put, the one-month price elasticity of oil supply is zero while the two-month elasticity is identical to that of the BH19-inspired calibration (see appendix A.3 for more details). The experiment allows us to isolate the effect of a change in the one-month elasticity of supply.

Imposing a perfectly inelastic oil supply in the very short run amplifies the effect of a global economic activity shock on oil prices but only in the short run (figure 4). The initial increase in oil prices is larger when oil supply is not allowed to respond within a month, but the gap with the baseline response of oil prices decays quickly. Even on impact, the difference between these two scenarios is limited, because inventories can be used to partially offset the delayed response of oil supply.

Figure 4: Global economic activity shocks and the one-month elasticity of oil supply



Blue: BH19 case: $\sigma_{SR} = \sigma_{LR} = 0.15$
Black: zero one-month elasticity of supply

An important implication of these results is that varying the one-month elasticity of oil supply while holding all other elasticities and parameters constant has only a limited direct impact on the effect of demand shocks on oil prices. The widely used restrictions on the one-month price elasticity of oil supply of K09, KM12 and KM14 thus have a limited direct impact on the relative contribution of global economic activity shocks – if they do not affect other parameters of the model.

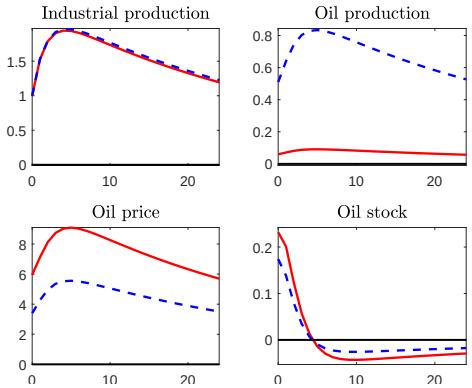
Since the SVAR literature is not only divided on the short-run drivers of oil prices, but also on what causes their fluctuations in the medium to long run, one can assume that these restrictions affect some other parameters of the model.[7] One possibility, which we discuss in the next sections, is that imposing a prior on the one-month price elasticity of oil supply has implications for the other three elasticities: the long-run price elasticity of oil supply and the price and income elasticities of oil demand.

4.2 Varying the short and long-run price elasticity of oil supply

A joint disagreement over the short and long-run price elasticities of oil supply – such as the one we described in section 2 for KM12 and BH19 – has the potential to strongly affect the dynamics of oil prices. To illustrate this point, we simulate the effects of an aggregate demand shock under two calibrations. The first calibration, inspired by the results of BH19, uses a value of 0.15 for both the short and long-run elasticities of oil supply. The second, inspired by KM12, has a value of 0.01 for both the short and long-run elasticities of oil

[7] CCI19 reports the 24-month ahead forecast error variance decomposition of oil prices; KM12 up to 18 months; BH19 and K09 describe their cumulative effects with an historical decomposition.

Figure 5: A joint shift in the short and long-run price elasticity of oil supply



Blue: BH19 case: $\sigma_{SR} = \sigma_{LR} = 0.15$
Red: KM14 case: $\sigma_{SR} = \sigma_{LR} = 0.01$

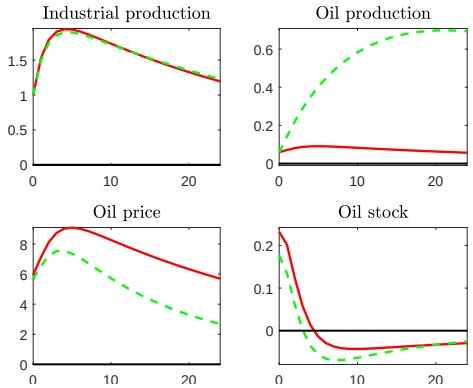
supply. Note that neither KM12 nor BH19 impose a value on this elasticity in the long run. However, it turns out that their IRF-implied elasticities are consistent with this calibration.

A more inelastic oil supply in the short- and long-run amplifies the response of oil prices to a global economic activity shock. An increase in global economic activity always stimulates the demand for oil, as captured by equation (8), which pushes up the price of oil. Higher oil prices then encourage final good producers to substitute oil inputs with other production factors and encourage oil producers to raise production. When oil supply is more inelastic (in red), all the adjustment goes through the demand for oil, and it takes a larger increase in oil prices to convince final good producers to substitute enough oil inputs with other production factors.

4.3 The long-run price elasticity of oil supply

Changes in the value of the long-run price elasticity of oil supply can substantially affect the dynamics of oil prices. We perform another experiment in which we calibrate the short-run price elasticity of oil supply to 0.01 and its long-run counterpart to 0.45 (our prior mode). Comparing the results of this simulation with the one inspired by KM12 allows us to isolate the role of this long-run elasticity. On impact, these two economies have the same price elasticity of supply. In the KM12-inspired economy, this elasticity remains low, while it gradually increases up to 0.45 in the other experiment. Note that the well depreciation rate is calibrated to have a half-life of two years, implying that about half of the adjustment from the short to the long-run elasticity takes place in two years. Simply put, the medium-run (two-year) elasticity is close to 0.23 when the long-run elasticity is set at 0.45.

Figure 6: Global economic activity shocks and the long-run elasticity of oil supply



Red: KM14 case: $\sigma_{SR} = \sigma_{LR} = 0.01$
Green: $\sigma_{SR} = 0.01$ *;* $\sigma_{LR} = 0.45$

When supply becomes more elastic in the long run, the price increase after an aggregate demand shock is much less persistent (see figure 6). The gradual increase in oil supply helps to mitigate the effect of higher oil demand on oil prices. The behavior of storage firms also depends on the medium-term response of oil supply. While storage firms find it optimal to sell their inventories when oil supply gradually increases in the medium run, they hold on to their inventories when they expect the imbalance between oil demand and supply to persist. Thus, in a model incorporating optimal storage decisions, the effect of an economic activity shock on oil prices is also stronger in the short run when the medium-term price elasticity of oil supply is lower.

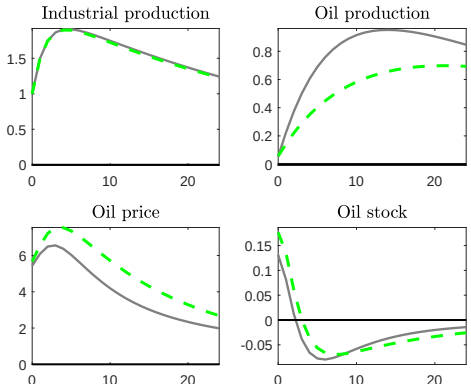
4.4 Adjustment speed towards the long-run elasticity

We now describe the impact of increasing the oil well decay rate, which effectively increases the adjustment speed of oil supply. We compare the effect of an aggregate demand shock when the half-life of oil wells is set to two years with an alternative value of one year. This experiment illustrates the importance of this parameter for the dynamics of oil prices, but may also shed some light on the possible future consequences of the shale oil revolution in the US, where production from unconventional wells decays at a faster rate.

Figure 7 shows that a faster supply adjustment strongly alters the dynamics of oil prices: the increase in oil prices is more muted in the medium run. Overall, we can also see that the effect of an increase in the adjustment speed on the dynamics of oil prices is similar to that of an increase in the long-run elasticity.

An important conclusion that emerges from our analysis is that while much attention has

Figure 7: Global economic activity shocks and the adjustment speed of oil supply



Green: $\sigma_{SR} = 0.01$ *;* $\sigma_{LR} = 0.45$ *; Half-life* $= (1-\delta)/\delta = 24$*;*
Grey: $\sigma_{SR} = 0.01$ *;* $\sigma_{LR} = 0.45$ *; Half-life* $= (1-\delta)/\delta = 12$

been paid to the short-run elasticity of oil supply, its long-run counterpart and the speed at which supply adjusts to shocks are also crucial in assessing the sources of oil price volatility. In SVARs, it is difficult to determine the value of a long-run elasticity. In contrast, it is easy to introduce a prior and estimate this elasticity in our RBC model because it depends on a few structural parameters. Moreover, one parameter - the oil well decay rate - determines the speed of supply adjustment to shocks. In section 5, we show how different assumptions about the short- and long-run elasticities interact, and we show that imposing different assumptions about the long-run elasticity and the adjustment speed of supply can lead to substantially different conclusions.

5 What are the main drivers of oil prices?

In this section, we revisit this question through the lenses of our RBC model. Our methodology offers two advantages over SVARs. First, we easily combine different well-accepted identification assumptions in a structurally simple and coherent framework. Second, we can introduce prior knowledge on the long-run elasticity and adjustment speed of oil supply.

We will highlight two crucial choices that have important repercussion on the relative contribution of demand and supply shocks for oil prices: one that is known, and one that is novel. First, we confirm the results of K09, KM12, KM14, BH19, and CCI19 that were summarized in Herrera and Rangaraju (2020): a lower short-run elasticity of oil supply translates into a lower contribution of supply shocks. Second, we show that a decision to introduce – or not – prior knowledge on the long-run elasticity and adjustment speed of oil

supply also has important repercussion on the sources of variation in world oil prices. A novelty of our paper is to show that one can find a non-negligible role for supply shocks, even when the short-run elasticity of oil supply is constrained to take a very low value. This was not possible in existing SVAR literature.

In this paper, we do not take a stand on the value of the short-run elasticity of oil supply. While it is clear that this value is low, we will consider different priors borrowed from influential papers in the SVAR literature. The advantage of this approach is to provide number that would remain robust to the development of new empirical evidence pointing towards different values of this short-run elasticity. Moreover, we can show that our main contribution – that the long-run elasticity matters – is robust to different priors on the short-run elasticity. In section 5.1, we present results inspired by the works of KM12 and KM14, where the short-run elasticity of oil supply is bounded below 0.0258. In section 5.2, we consider a case inspired by the prior of CCI19 (similar to BH19), with a prior centered around 0.08 for this parameter. The difference between these experiments - as well as their relatively large confidence bands - will also point at a relatively large uncertainty about the role of supply shocks.

5.1 The long-run elasticity and the adjustment speed matter

To evaluate the importance of introducing a prior on the long-run elasticity of oil supply, we will compare the results of a first benchmark model - that introduces an uninformative prior on the long-run elasticity - to our preferred estimates that exploit prior knowledge about the long-run elasticity. Note that in both cases, we use an informative prior for the adjustment speed of supply as described in section 3.7. Later in this section, we will show that varying the prior for the adjustment speed also matters.

The variance decomposition in Table 3 shows that demand shocks are the sole important drivers of oil prices in the benchmark. These results confirm those of KM14 in a RBC framework. When the short-run elasticity of oil supply is low, and when we do not exploit prior knowledge about its long-run value, oil supply shocks play a marginal role.

However, these results hinge upon a low long-run elasticity that is inconsistent with actual prior knowledge about this parameter. The posterior mode is at 0.05, while in the mode in the literature is at 0.45, about 9 times larger. As displayed in the upper left panel of figure 8, the elasticity of supply stays relatively constant across the time dimension. In this benchmark case, the adjustment speed becomes almost irrelevant: the short and long-run elasticities are so close to one another and the long-run elasticity is so low that supply is

Table 3: Variance decomposition: KM-inspired cases

	Oil Supply	**Aggregate Demand**	**Oil-consump Demand**	**Oil-invent Demand**
Flat LR prior				
Oil prod	90.4	3.24	5.18	0
Ind prod	0.3	85.16	14.14	0
Oil price	7.06	30.82	59.55	0.02
68%	(4.93 ; 10.31)	(21.13 ; 42.6)	(50 ; 71.57)	(0.01 ; 0.04)
95%	(3.63 ; 14.92)	(15.27 ; 53.71)	(41.46 ; 78.59)	(0.01 ; 0.08)
Oil stock	4.2	6.16	14.17	74.33
Tight LR prior				
Oil prod	70.35	12.15	14.96	0
Ind prod	0.73	87.72	11.28	0
Oil price	15.85	24.57	57.47	0.03
68%	(11.7 ; 21.39)	(19.52 ; 32.05)	(50.28 ; 64.6)	(0.02 ; 0.07)
95%	(8.92 ; 27.75)	(15.62 ; 46.7)	(38.43 ; 69.33)	(0.01 ; 0.11)
Oil stock	2.3	4.62	19.48	73.29

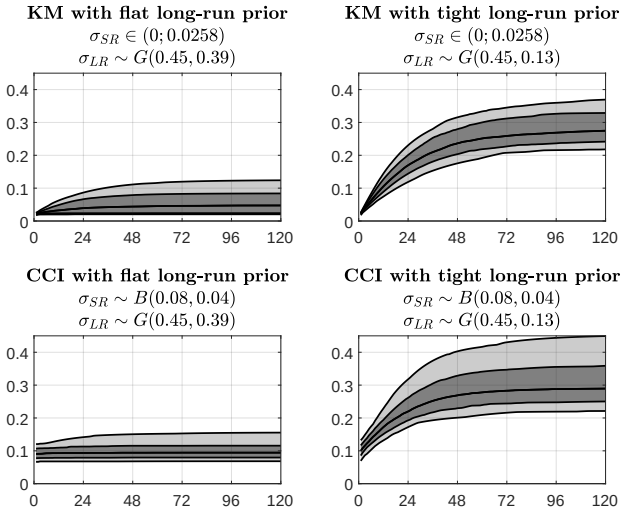
almost perfectly inelastic at all horizons.

Our next step is thus to impose an informative prior on the long-run elasticity, with a mode chosen to fit the literature, at 0.45. With this prior, we end up with short and long-run elasticities that falls within bounds of prior studies. The posterior mode of the short and long-run elasticities of supply are estimated to 0.02 and 0.26. The transition from short to long-run elasticities is half-way through in 2 years; and almost complete in 5 years (Upper left panel of figure 8). The one-year elasticity is a bit above 0.1, which is also supported by Bornstein et al. (2023) and Bogmans et al. (2024). In that case, the response of oil supply is consistent with the literature, not only on impact, but across all horizons.

It turns out that imposing a prior on the long-run elasticity of oil supply affects the relative importance of supply and demand for oil prices. The contribution of supply shocks increases from 7% in the benchmark case, to 16% with our long-run prior. This result stands in contrast with the SVAR literature, that has typically ascribed a marginal role to supply shocks, when imposing small values on the short-run price elasticity of oil demand.

Finally, we experiment with a change in the prior for the adjustment speed of supply. We contrast our estimate that uses prior knowledge about the long-run elasticity and adjustment speed of supply to an alternative where the prior for the adjustment speed is almost uninformative. In this latter case, results are similar to the KM-inspired benchmark. Without an informative prior, the adjustment speed is much slower: the parameter δ falls to 0.017 corresponding to an half-life of five years, and supply shocks explain about 12% of the fluctuations in oil prices (down from 16% with the informative prior). The conclusion is that the

Figure 8: Supply elasticities at different horizons



This figure displays the posterior distribution of our supply elasticities at different horizons. Elasticities are approximated using the ratio of impulse response of oil supply to that of oil prices after an aggregate demand shock. Intuitively, it thus displays the impulse response of oil supply to a permanent increase in oil prices of 1%. We vary the prior for the short and long-run elasticities in the four panels, while all other calibrated parameters and priors remain unchanged and are described in section 3.7.

priors for the long-run elasticity and adjustment speed both matters to evaluate the relative importance of supply and demand shocks for oil prices.

5.2 Uncertainty about the importance of supply shocks?

In this section, we borrow the prior for the short-run elasticity of oil supply from CCI19, which has a mean of 0.08 and standard deviation of 0.04, and use an informative prior about the long-run elasticity and adjustment speed of oil supply. The results from this experiment are summarized in Table 4. We find that oil supply shocks explain about one-third of the variance in oil prices. This experiment attributes a larger share of oil prices fluctuations to oil supply shocks compared to that inspired by KM14. The reason is that the estimated short- and long-run price elasticities of oil supply are larger, which is consistent with our discussion in the previous section.

Incorporating prior knowledge on the long-run price elasticity of oil supply also matters in this case. With a relatively flat prior, the mode of this parameter falls from 0.31 to 0.09, and the contribution of oil supply shocks to oil prices falls from 36 to 17%.

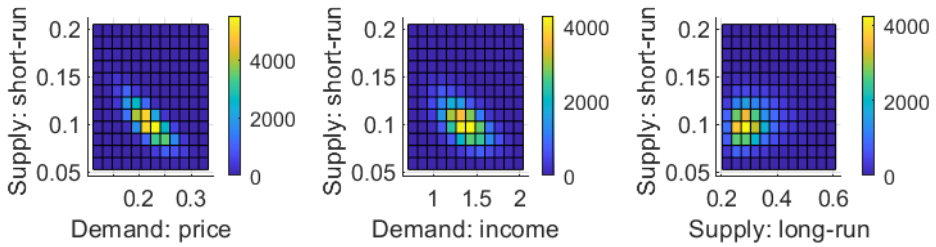
We also document a large uncertainty around the contribution of oil supply shocks. Indeed, we cannot completely rule out the possibility that oil supply shocks explain the

Table 4: Variance decomposition: CCI-inspired cases

	Oil Supply	**Aggregate Demand**	**Oil-consump Demand**	**Oil-invent Demand**
Flat LR prior				
Oil prod	61.38	12.12	25.16	0.01
Ind prod	0.66	90.02	9.02	0
Oil price	16.91	24.99	55.45	0.03
68%	(11.84 ; 23.22)	(18.91 ; 36.97)	(46.03 ; 65.23)	(0.02 ; 0.06)
95%	(7.92 ; 32.09)	(12.88 ; 47.05)	(36.06 ; 74.32)	(0.01 ; 0.09)
Oil stock	7.21	3.82	9.04	79.96
Tight LR prior				
Oil prod	55.46	16.09	26.14	0.01
Ind prod	1.83	92.67	5.17	0
Oil price	35.86	18.14	43.46	0.05
68%	(26.76 ; 46.22)	(12.82 ; 25.08)	(35.21 ; 52.72)	(0.03 ; 0.08)
95%	(19.37 ; 63.69)	(9.27 ; 33.74)	(25.82 ; 61.38)	(0.01 ; 0.13)
Oil stock	4.43	2.88	12.75	79.86

majority of oil price fluctuations: the odds that oil supply shocks explain 50% of the variance in oil prices stand close to 10%. These results are surprising considering that we build a model that combines different identifying restrictions used in the SVAR literature with prior studies of the oil market in a single framework. This high level of uncertainty has two origins. First, small changes in the value of key elasticities have an important repercussion on the dynamics of oil prices. Second, the multivariate posterior distribution of the elasticities shows a correlation in the elasticities that magnifies the uncertainty in the FEVD.

Figure 9: Relation between the short-run price elasticity of oil supply and other elasticities



Note: Histogram representing the bivariate distribution of the short-run elasticity of supply with one other elasticity based on 50 000 MCMC draws.

Indeed, the relationship that we described above between the short-run elasticity of oil supply in the other elasticities is also present in the joint distribution of the parameters in our baseline estimation. Figure 9 sequentially plots the MCMC draws of the short-run elasticity of oil supply with the other tree elasticities. It shows that the parameter draws

displaying a lower supply elasticity in the short run tend to be associated with a lower supply elasticity in the long-run, a higher price elasticity of demand, and a higher output elasticity of demand (and vice-versa). This correlation bears repercussion for the confidence bands of the variance decomposition we showed above, because we can easily find combinations of draws for which all elasticities would tend to produce a high contribution of supply shocks, as well as the exact opposite. Intuitively, the correlation in the MCMC draws means that the uncertainty around the parameters estimates compounds to produce wider confidence bands of the FEVD.

We also identify the MCMC draws that attributes more than 50% of the FEVD of oil prices to supply shocks and compare these draws to the others (figure 13 in the appendix). A similar pattern stands out: these draws tend to combine a higher-than-average supply elasticity in the short and long run with a high adjustment speed of supply and a lower price and income elasticities of demand. Moreover, the variance and the persistence of supply shocks tend to be higher.

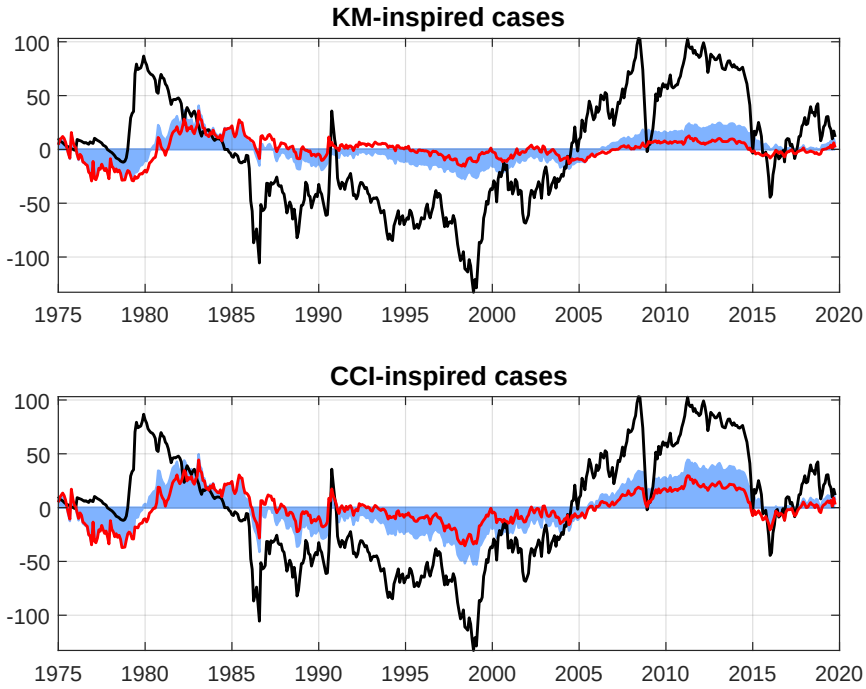
5.3 When did supply shocks mattered?

The historical decomposition in figure 10 reveals that oil supply shocks do play a non-negligible role. In the four cases we consider – that uses different priors on the short and long-run elasticity of oil supply – oil supply shocks contributed to the high prices observed in the first half of the 80s, in the years preceding the GFC, and during its recovery. We can also see that introducing an informative prior for the long-run elasticity matters for the historical decomposition: oil supply shocks do play a more important role when this prior knowledge is used.

A succession of adverse supply shocks resulted in a strong upward pressure on oil prices in the early 80s. The Iranian revolution in 1979 was followed by the Iran-Iraq war, which began in September 1980 and lasted for eight years. In this period, the OPEC group also tried to proactively counter the fall of oil prices from their 1979 peak. Our results indicate that, together, these supply shocks mitigated the return of oil prices towards their equilibrium level, that would have been much faster without these shocks. The 1986 oil price collapse is then explained by a combination of weak demand and abundant supply, in part due by Saudi Arabi, that reversed its policy of responding to falling oil prices with lower production.

Oil supply shocks also contributed to the rise in oil prices observed after the GFC. Potential explanation for these shocks include the Libyan uprising in 2011 and the sanctions imposed on Iran in 2012. The effect of oil supply shocks is also visible during the commodity

Figure 10: Historical contribution of supply shocks to oil prices fluctuations



Note: Black: actual oil price fluctuations.
Blue: oil supply shocks contribution with informative prior on σ_{LR}
Red: oil supply shocks contribution with flat prior on σ_{LR}.

price slump, coinciding with the rapid growth of US shale and Iran's return to the market, although this effect is small when using the short-run prior inspired by KM12.

The peak in oil prices reached in 1979 is however explained by a combination of global economic activity as well as oil consumption and inventory demand (the latter could be related to the higher uncertainty that followed the Iranian revolution), which echoes the results of Barsky and Kilian (2002) and KM14. The contribution of global economic activity shocks then turned negative as the economy weakened after Volcker raised policy rates in the US. In that period, the contribution of oil-specific demand shocks turned from positive to negative, potentially reflecting efforts to reduce the use of oil following the two major oil crises of the 70s. Global economic activity shocks also were a key determinant of oil prices during the early-90s recession.

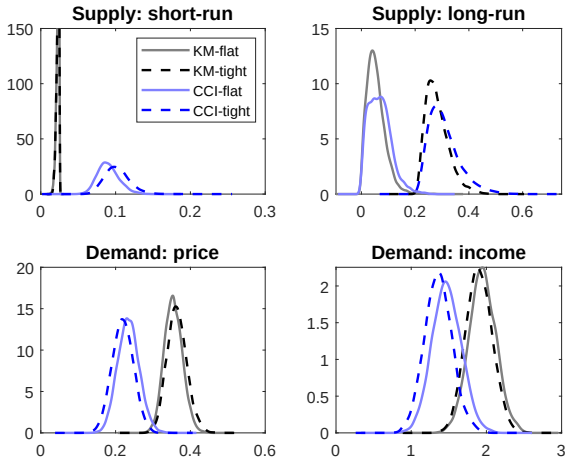
Our results also confirms those of K09 that attributes the oil price boom in the early 2000s to the cumulative effect of aggregate demand shock – even when using the prior of CCI19 for the short run elasticity and our informative prior for the long-run elasticity. Global economic activity shocks were also a crucial driver of oil prices during the GFC and its recovery, and

also explains about one-third of the fall in oil prices during the commodity price slump in 2015/16.

5.4 How realistic are our supply and demand elasticities?

Figure 11 shows that our estimated supply and demand elasticities take reasonable values. The short-run price elasticity of supply reflects the prior: its mode is 0.02 when implementing the bound of KM12 and KM14, while its mode is at 0.1 with the prior borrowed from CCI19. It is noteworthy that our macro data support relatively higher estimates for this elasticity: the posterior mean is always higher than the prior mean.

Figure 11: Posteriors distributions of oil elasticities



Note:

The estimated long-run price elasticity of supply is relatively small compared to the literature, but still reasonable according to the few estimates that are available when an informative prior is used. The fact that this elasticity plays an important role even with conservative values mean that we probably underestimate its effect on the FEVD of oil prices. The price elasticity of demand is also reasonable, and as explained in Herrera and Rangaraju (2020), it is larger when the short-run elasticity of supply is lower (about 0.35 in the KM cases compared to 0.22 in the CCI19 cases). The income elasticity of demand lies in the upper range of available estimates. The income elasticity of oil demand is also higher when the short-run price elasticity of demand is lower.

5.5 What does it take for supply shocks to dominate?

In this section, we compute the contribution of supply shocks to oil prices for different calibrated values of the short and long-run elasticities of oil supply. The other parameters are estimated. The mode of the FEVD for each pairs of elasticities are reported in table 5.

Table 5: Contribution of supply shocks to oil prices

	$\sigma_{\text{LR}} = 0.1$	$\sigma_{\text{LR}} = 0.25$	$\sigma_{\text{LR}} = 0.50$	$\sigma_{\text{LR}} = 1$
$\sigma_{\text{SR}} = 0.001$	7.43	10.86	17.52	20.67
$\sigma_{\text{SR}} = 0.025$	8.61	13.04	21.27	24.88
$\sigma_{\text{SR}} = 0.05$	11.43	17.87	29.15	33.59
$\sigma_{\text{SR}} = 0.10$	19.15	29.65	46.06	51.52

This exercise confirms that one can only obtain a very small (FEVD$<$10%) contribution of oil supply shocks by combining small elasticities of oil supply in the short and long runs. Moreover, oil supply shocks potentially become dominant drivers of oil prices fluctuations, when the long-run elasticity is set to one and the short-run elasticity is set at a value of 0.1 that is consistent with those of BH19 and CCI19.

These results also show that for a given value of the short-run elasticity, varying the long-run elastricity strongly affects the FEVD. This indicates that uncertainty about the long-run elasticity translates into larger uncertainty about the FEVD. Our results should motivate the development of new methods to integrate restrictions about long-run elasticities in SVAR models, and to exploit micro data to estimate this long-run elasticity.

6 Conclusion

In this paper, we show how one can introduce priors on the short- and long-run elasticities of oil supply, on its adjustment speed, and on the price and income elasticities of oil demand in a simple RBC model. The ability to introduce priors on the adjustment speed and long-run elasticity of oil supply is advantage of our framework compared to SVAR models, where these factors depend on a complex function of many parameters.

We use our model to shed light on the SVAR debate regarding the sources of oil prices fluctuations. This debate centers on different assumptions on the short-run price elasticity of oil supply in SVAR models. We find the adjustment speed and the long-run elasticity of oil supply alter the transmission of structural shocks to oil prices in our RBC model, whereas the short-run elasticity alone does not. We estimate the model with Bayesian

methods using monthly data and incorporating priors on the key parameters. The results show that incorporating prior knowledge of the long-run elasticity and adjustment speed of oil supply plays a key role in estimating the relative importance of supply and demand shocks in driving oil prices. In our conservative estimate, oil supply shocks account for about 16% of the variation in oil prices. This value falls to 7% when we assume uninformative prior on the long-run elasticity. We also discuss estimation results using various priors for the short- and long-run elasticities discussed in the literature.

Our results support the view that demand factors are the most likely dominant factors in explaining oil prices fluctuations, although supply shocks do play a non-negligible role. However, uncertainty around the oil market elasticities translate into substantial uncertainty in oil prices dynamics, implying that we find a small possibility that oil supply shocks might dominate oil demand shocks.

While we leave this issue for future research, our methodology could inspire the calibration of models that study the costs of a green transition. In these models, the long-run elasticities of commodity demand and supply are crucial and have an important effect on the cost estimates. Our framework could easily be extended to introduce multiple commodities that will be required in this transition.

A Oil market elasticities

A.1 The short-run elasticity of oil supply

The short-run price elasticity of oil supply is defined as the percentage change in the quantity supplied divided by the percentage change in the price of oil within one month. In this appendix, we show in detail how we obtain a closed-form solution for this elasticity.

We begin by describing the objective of oil producers (the production technology is described in the model section of the paper). Oil producer are risk-neutral and derive utility from their profits $\Pi_t(o)$ and dis-utility from hours worked in the wells. Their objective is to maximize

$$\mathrm{E}_0^j \sum_{t=0}^{\infty} \beta^t \left[\Pi_t(o) - wH_t(o)\right],$$

where β is their discount factor, w is a fixed disutility from hours worked and $\Pi_t(o) = p_t(o)Y_t(o) - I_t(f)$. one could thus also interpret $\Pi_t(o)$ as the profits before wages and $wH_t(o)$ as the wage bill. In this expression, $p_t(o)$ is the real price of oil and we assume that investment goods are produced with one unit of the final good: the real price of investment is thus simply equals to one.

The first order conditions w.r.t. hours worked is $p_t(o)\frac{\partial Y_t(o)}{\partial H_t(o)} = w$. Developing gives:

$$w = p_t(o)(1-\alpha_o)^{\frac{1}{\Theta_o}} \left(\frac{H_t(o)}{Y_t(o)}\right)^{-\frac{1}{\Theta_o}} (\varepsilon_t^{os})^{\frac{\Theta_o - 1}{\Theta_o}} \tag{14}$$

Isolate $H_t(o)$:

$$H_t(o) = (1-\alpha_o)Y_t(o) \left(\frac{p_t(o)}{w}\right)^{\Theta_o} (\varepsilon_t^{os})^{(\Theta_o - 1)} \tag{15}$$

At steady-state, assuming that $w = p(o)$, we have $H(o) = (1-\alpha_o)Y(o)$. Linearizing this expression gives a familiar expression:

$$\hat{H}_t(o) = \hat{Y}_t(o) + \Theta_o \hat{p}_t(o) - (1-\theta_o)\hat{\varepsilon}_t^{os} \tag{16}$$

Linearizing the production function gives:

$$\hat{Y}_t(o) = (1-\alpha_o)\,\hat{H}_t(o) + \alpha_o\,\hat{\Lambda}_t(o) \tag{17}$$

To find a closed-form solution for the short-run elasticity of oil supply, we assume that the stock of wells is fixed at its steady state (it takes one period to invest in new wells, so $\hat{\Lambda}_t(o) = 0$ in the short run) and that there are no supply shocks ($\hat{\varepsilon}_t^{os} = 0$). Plugging the linearized labor demand equations (16) into the production function:

$$\hat{Y}_t(o) = \frac{\Theta_o(1-\alpha_o)}{\alpha_o}\hat{p}_t(o) \tag{18}$$

A.2 The long-run elasticity of oil supply

The long-run price elasticity of oil supply (LRPEOS) is measured as the change in the quantity of oil supplied in the long-run in response to a permanent one percent increase in the price of oil. In this appendix, we show in detail how we obtain a closed-form solution for this elasticity. We already derived the FOC w.r.t. hours worked in the previous section and now turn to the FOC w.r.t. investment since this decision will also affect the long-run elasticity.

Let us also break the oil producer problem in two, which does not affect the model, but simplifies the exposition of the FOCs. First, let us compute a demand function for wells - steaming for example from an assumption that oil producers can rent wells to one an other at the rate R_t^{Λ}. This FOC is similar to that of hours:

$$r_t^{\Lambda}(o) = p_t(o)(\alpha_o)^{\frac{1}{\Theta_o}}\left(\frac{\Lambda_t(o)}{Y_t(o)}\right)^{-\frac{1}{\Theta_o}}(\varepsilon_t^{os})^{\frac{\Theta_o-1}{\Theta_o}} \tag{19}$$

At steady-state, let us assume that $r^{\Lambda}(o) = p(o)$ such that $\alpha_o = \frac{\Lambda_t(o)}{Y_t(o)}$. Already note that we will calibrate A_o such that this holds (more details later). After linearization, we obtain:

$$\hat{\Lambda}_t(o) = \hat{Y}_t(o) + \Theta_o\left(\hat{p}_t(o) - \hat{r}_t^{\Lambda}(o)\right) - (1-\Theta_o)\hat{\varepsilon}_t^{os} \tag{20}$$

Note that the rental rate of wells equals its marginal products, so that the decision of investing in a well is independent from the decision of using the well for its own production or renting the well to another producer. When investing in a new well, oil producers maximize:

$$\beta\sum_{s=0}^{\infty}(1-\delta)^s\beta^s r_{t+1+s}^{\Lambda}\Lambda_t^* - I_t \tag{21}$$

where the first terms represent the discounted values (starting in the next period) of the future income associated with a new well that depreciate at the rate δ, and the second term

is the investment cost (one unit of investment requires one unit of final good). The FOC is:

$$\sum_{s=0}^{\infty}(1-\delta)^s\beta^s r^{\Lambda}_{t+1+s}\frac{\partial\Lambda^*_t}{\partial I_t}=\frac{1}{\beta} \tag{22}$$

where

$$\frac{\partial\Lambda^*_t}{\partial I_t}=A_o^{\frac{\theta_o-1}{\theta_o}}(1-\gamma_o)^{\frac{1}{\theta_o}}\left(\frac{I_t}{\Lambda^*_t}\right)^{-\frac{1}{\theta_o}} \tag{23}$$

and the parameter A_o is used as a normalizing constant and calibrated such that $r^{\Lambda}(o)=p(o)=1$ holds in the steady state. After linearization:

$$\sum_{s=0}^{\infty}(1-\delta)^s\beta^s\left[\hat{r}^{\Lambda}_{t+1+s}-\frac{1}{\theta_o}\left(\hat{I}_t-\hat{\Lambda}^*_t\right)\right]=0 \tag{24}$$

In the long-run (when t goes to ∞), this expression simplifies to

$$\hat{r}^{\Lambda}_t=\frac{1}{\theta_o}\left(\hat{I}_t-\hat{\Lambda}_t\right) \tag{25}$$

because $\hat{\Lambda}^*_t=\hat{\Lambda}_t$ and $\hat{r}_{t+1+s}$ converges to its equilibrium value and stays constant over time. Linearizing the well production function gives $\hat{\Lambda}_t=(1-\gamma_o)\hat{I}_t$, as the stock of land is fixed.

Finally, we end up with a system of five equations given by:

$$\hat{r}^{\Lambda}_t=\frac{1}{\theta_o}\left(\hat{I}_t-\hat{\Lambda}_t\right) \tag{26}$$

$$\hat{\Lambda}_t=(1-\gamma_o)\hat{I}_t \tag{27}$$

$$\hat{\Lambda}_t=\hat{Y}_t+\Theta_o\left(\hat{p}_t-\hat{r}^{\Lambda}_t\right) \tag{28}$$

$$\hat{H}_t=\hat{Y}_t+\Theta_o\hat{p}_t \tag{29}$$

$$\hat{Y}_t=(1-\alpha_o)\,\hat{H}_t+\alpha_o\,\hat{\Lambda}_t \tag{30}$$

where the last two equations were derived in the previous section. Solving yields:

$$\hat{Y}_t=\left[\frac{\Theta_o(1-\alpha_o)}{\alpha_o}+\frac{\theta_o(1-\gamma_o)}{\alpha_o\gamma_o}\right]\hat{p}_t \tag{31}$$

where the term in brackets is the long-run elasticity.

A.3 Imposing a zero elasticity of oil supply on impact

We show how we can impose a zero elasticity of oil supply on impact (one month) while leaving this elasticity unchanged over all other horizons. We simply assume that hours worked are set one period in advance. Under this assumption, all production factors are fixed over a one-month horizon and the supply elasticity is thus zero. Starting in the second month after a shock, the elasticity is identical to that of the baseline model. Specifically, the production function is:

$$Y_t(o) = \varepsilon_t^{os} \left[(1-\alpha_o)^{\frac{1}{\Theta_o}} H_{t-1}(o)^{\frac{\Theta_o-1}{\Theta_o}} + (\alpha_o)^{\frac{1}{\Theta_o}} \Lambda_t(o)^{\frac{\Theta_o-1}{\Theta_o}} \right]^{\frac{\Theta_o}{\Theta_o-1}} \tag{32}$$

The first order conditions w.r.t. hours worked is $\mathrm{E}_t p_{t+1}(o) \frac{\partial Y_{t+1}(o)}{\partial H_t(o)} = w$. In this case, the impact elasticity is zero because hours and the new oil wells are both predetermined: on impact, nothing can be done to adjust production to an unexpected change in prices. The long-run elasticity is unchanged and from the second month onwards, we can shows that this elasticity is numerically equivalent to that of our baseline model.

A.4 The price and income elasticities of oil demand

Final good producers maximize their profits given by

$$Y_t(f) - w_t H_t(f) - r_t^k(f) K_t(f) - p_t(o) O_t(f)$$

where the final good is used as a numeraire to express all prices in real terms and $p_t(o)$ is the real price of oil (deflated with the price of the final good). The first order condition w.r.t. oil inputs is $\frac{\partial Y_t(f)}{\partial O_t(f)} = p_t(o)$. Developing gives:

$$p_t(o) = (\omega_o)^{\frac{1}{\eta_o}} (\varepsilon_t^{od})^{\frac{\eta_o-1}{\eta_o}} \left(\frac{O_t(f) - \bar{O}}{Y_t(f)} \right)^{-\frac{1}{\eta_o}} \tag{33}$$

We then assume that $p(o) = 1$ at steady state, which simply reflects a choice of unit. It implies that $\omega_o = \frac{O_t(f)-\bar{O}}{Y_t(f)}$. Isolate $O_t(f)$:

$$O_t(f) = \bar{O} + \omega_o Y_t(f) p_t(o)^{-\eta_o} (\varepsilon_t^{od})^{\eta_o - 1} \tag{34}$$

Linearize to obtain the oil demand curve:

$$\hat{O}_t(f) = \frac{O(f) - \bar{O}}{O(f)} \left[\hat{Y}_t(f) - \eta_o \hat{p}_t(o) - (1 - \eta_o) \hat{\varepsilon}_t^{od} \right] \tag{35}$$

To properly introduce prior knowledge on the output and price elasticities of oil demand and to simplify their estimation, we express equation (35) as

$$\hat{O}_t(f) = \chi_{\text{Y}} \hat{Y}_t(f) - \chi_{\text{P}} \hat{p}_t(o) - \hat{\varepsilon}_t^{od} \tag{36}$$

where $\chi_{\text{Y}} = \frac{O(f)-\bar{O}}{O(f)}$ is the output elasticity of oil demand and $\chi_{\text{P}} = \eta_o \frac{O(f)-\bar{O}}{O(f)}$ is the price elasticity of oil demand. It implies that the structural parameters are retrieved from these elasticities as $\bar{O} = (1 - \chi_{\text{Y}})O(f)$ and $\eta_o = \frac{\chi_{\text{P}}}{\chi_{\text{Y}}}$. Also note the size of the shock is rescalled by a factor of $\frac{\chi_{\text{Y}} - \chi_{\text{P}}}{\chi_{\text{Y}}}$ which has no effect on the estimation.

B More details on the model

B.1 The households's problem

The FOC w.r.t. C_t, $H_t(f)$, B_t, $K_t(f)$ and $I_t(f)$ are:

$$(C_t - \mathbf{b} C_{t-1})^{-\sigma_c} = \lambda_t \tag{37}$$

$$A_h H_t^{\sigma_h} = \lambda_t w_t \tag{38}$$

$$\lambda_t = \beta R_t \mathrm{E}_t \lambda_{t+1} \tag{39}$$

$$\mu_t = \beta \mathrm{E}_t \left(\lambda_{t+1} r_{t+1}^k + (1 - \Delta) \mu_{t+1} \right) \tag{40}$$

$$\lambda_t = \mu_t \left(1 - \tfrac{\phi}{2} \left(\tfrac{I_t}{I_{t-1}} - 1 \right)^2 - \phi \left(\tfrac{I_t}{I_{t-1}} - 1 \right) \tfrac{I_t}{I_{t-1}} \right) + \beta \mathrm{E}_t \mu_{t+1} \phi \left(\tfrac{I_{t+1}}{I_t} - 1 \right) \left(\tfrac{I_{t+1}}{I_t} \right)^2 \tag{41}$$

where λ and μ are the shadow values associated with constraints (12) and (13). Let $P_t^k = \frac{\mu_t}{\lambda_t}$ and linearize:

$$\hat{w}_t = \sigma_h \hat{H}_t + \tfrac{\sigma_c}{1-b} \left(\hat{C}_t - b \, \hat{C}_{t-1} \right) \tag{42}$$

$$\hat{C}_t = \tfrac{1}{1+b} \hat{C}_{t+1} + \tfrac{b}{1+b} \hat{C}_{t-1} - \tfrac{1-b}{\sigma_c (1+b)} \hat{R}_t \tag{43}$$

$$\hat{p}_t^k = (1 - \beta(1 - \Delta)) \, \hat{r}_{t+1}^k + \beta(1 - \Delta) \hat{p}_{t+1}^k - \hat{R}_t \tag{44}$$

$$\hat{I}_t = \tfrac{1}{1+\beta} \hat{I}_{t-1} + \tfrac{\beta}{1+\beta} \hat{I}_{t+1} + \tfrac{1}{(1+\beta)\phi} \hat{p}_t^k \tag{45}$$

B.2 Calibration and estimation of standard parameters

For the investment adjustment cost and habit parameters, we use the priors of Smets and Wouters (2007) (SW07). Specifically, we set the prior mean of the habit parameter to 0.85, resulting in a similar persistence that that assumed by SW07 (0.7 with quarterly data). For shocks' variance and autoregressive parameters, we use standard priors. Specifically, we set the mean of prior of the autoregressive parameters to $0.8^{(1/3)}$ to match a value often used when working with quarterly data. The share of oil in the production basket is calibrated to match the total oil market value to the world industrial production.

Table 6: Calibration, priors & posteriors

Calibrated parameters	Value			
Depreciation rate of capital	0.025/3			
Capital income share (final good)	0.33			
Discount factor	$0.99^{1/3}$			
Inter-temporal elast. for consumption	1			
Labour supply elasticity	2			
Oil share in industrial production	0.05			
Oil inventories to production ratio	1.08			
Investment adjust. cost (final good)	12			
Estimated parameters	**Prior mean**	**Pr std**	**Post KM-wide**	**Post CCI-wide**
Habits in consumption	0.85	0.05	0.64	0.60
Storage demand elast. to Δprice	0.2	0.1	0.19	0.18
Price elasticity of oil demand	0.2	0.1	0.36	0.22
Income elasticity of oil demand	1	0.25	1.89	1.37

Note: Post KM-wide is the posterior of our estimated model where the prior for short-run elasticity of supply is constrained to be below 0.028. Post CCI-wide is the posterior of our estimated model where the mode of the prior for short-run elasticity of supply is set to 0.08. For both, the priors on the long-run elasticity and adjustment speed of supply are informative and described in section 3.7.

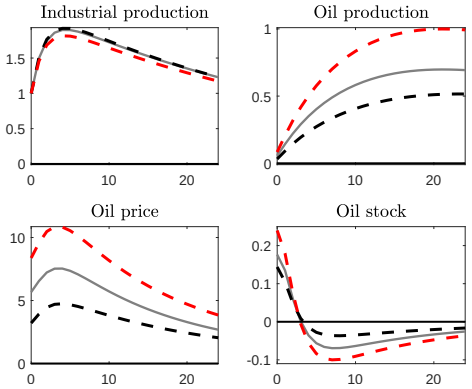
C Additional results

C.1 The price and income elasticities of oil demand: IRFs

We already discussed the possible link between the short and long-run elasticities of supply. Another possibility is that imposing a lower (higher) short-run price elasticity of oil supply affects the estimated oil demand elasticity. This point is raised in BH19, CCI19 and Herrera and Rangaraju (2020), who noted that in SVAR studies, a low supply elasticity in the short run tend to come with a large price elasticity of oil demand.

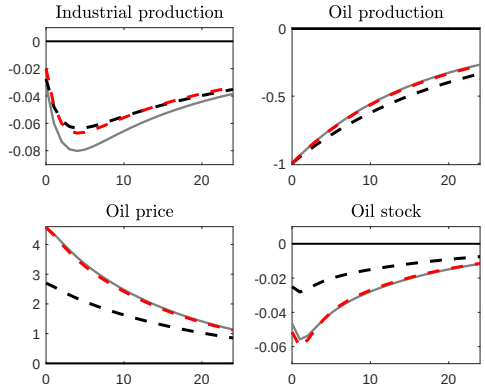
Figure 12: Oil demand elasticity and the transmission shocks

(a) Global economic activity shocks



Grey: $\chi_P = 0.20$ *and* $\chi_Y = 1$
Black: $\chi_P = 0.35$ *and* $\chi_Y = 1$
Red: $\chi_P = 0.20$ *and* $\chi_Y = 1.5$

(b) Oil supply shocks



Grey: $\chi_P = 0.20$ *and* $\chi_Y = 1$
Black: $\chi_P = 0.35$ *and* $\chi_Y = 1$
Red: $\chi_P = 0.20$ *and* $\chi_Y = 1.5$

In figure 12, we experiment with an increase in the price elasticity of oil demand. Specifically, we increase the value of parameter χ_P from 0.20 (the value of our prior mode) to 0.35 (as in BH19). A higher demand elasticity mitigates both the effect of global economic activity and oil supply shocks. The higher this elasticity, the easier it is for firms to substitute oil with other inputs, when the economy is faced with a favorable global economic activity shock, or when faced with an exogenous reduction in oil supply. A reduction in this demand elasticity, alone, is thus unlikely to affect the relative contribution of global economic activity and oil supply shocks. However, the relative contribution of oil consumption demand shocks is likely to rise, if the combined effect of aggregate demand and oil supply shocks declines.

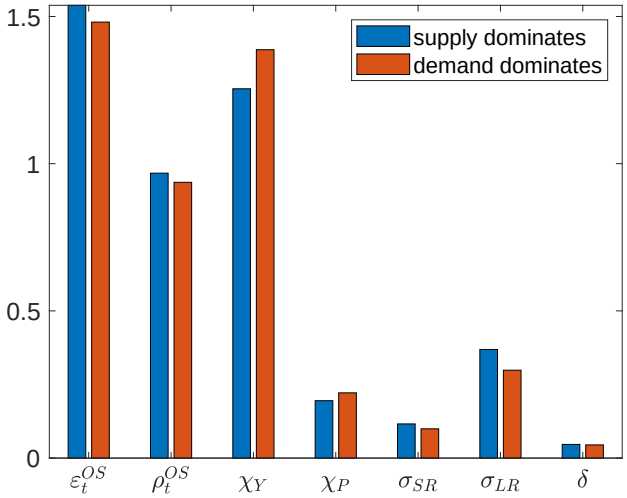
Finally, we consider the potential effect off increasing the income elasticity of oil demand (χ_Y), from one in the baseline, to 1.5. A higher income elasticity of oil demand amplifies the effect of global economic activity shocks on oil prices but does not affect the transmission of

oil supply shocks.

Overall, we thus showed that a decrease in the short and long-run price elasticity of oil supply combined with an increase in oil demand elasticities can shift the FEVD towards a lower relative contribution of oil supply shocks. To determine which shock dominates, it is thus important to pay a close attention to the value of all these elasticities. This is what we do in the paper, paying a particular attention to the long-run price elasticity of oil supply, which has not been discussed much in the SVAR literature.

C.2 When do supply shocks dominate in the CCI-wide model ?

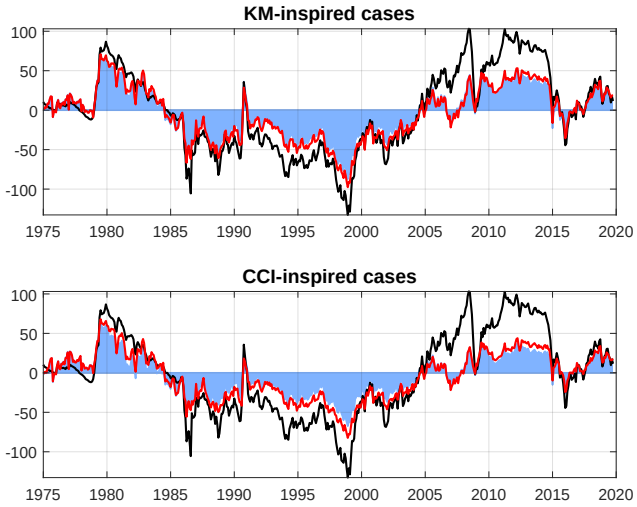
Figure 13: Characteristics of draws for which supply or demand dominates



Note: Average values of some estimated parameters for the 23 MCMC draws (out of 250 for this plot) for which supply shocks explain more than 50% of the FEVD of oil prices, compared to the averages for the 227 draws for which demand dominates.

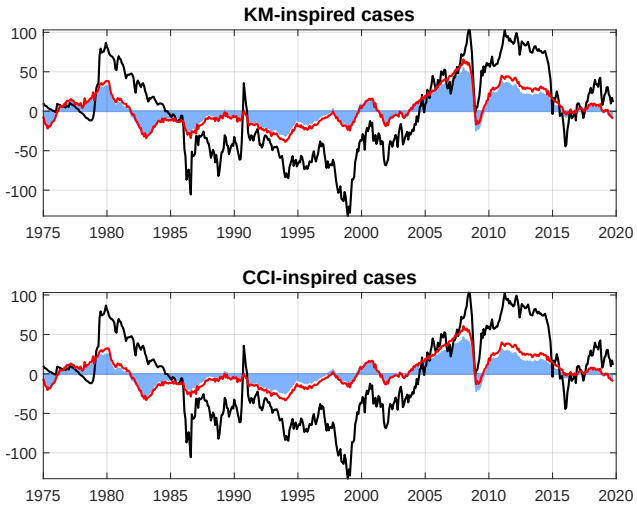
C.3 Contribution of demand shocks

Figure 14: Historical contribution of oil consumption demand shocks to oil prices fluctuations



Note: Black: actual oil price fluctuations.
Blue: oil consumption demand shocks contribution with informative prior on σ_{LR}
Red: oil consumption demand shocks contribution with flat prior on σ_{LR}.

Figure 15: Historical contribution of aggregate demand shocks to oil prices fluctuations

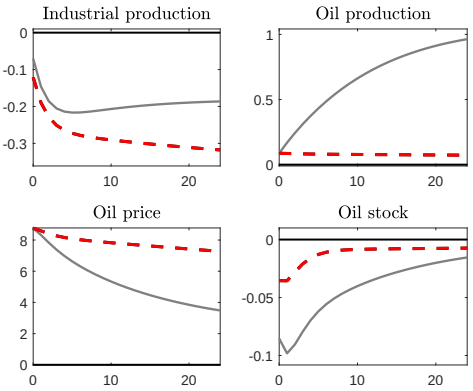


Note: Black: actual oil price fluctuations.
Blue: aggregate demand shocks contribution with informative prior on σ_{LR}
Red: aggregate demand shocks contribution with flat prior on σ_{LR}.

C.4 Persistent oil-demand shocks and the long-run elasticity

We now show the effect of a persistent oil-demand shock with an AR(1) parameter calibrated to 0.99 with different values of the long-run elasticity of oil supply. It shows that an oil demand shock has a stronger effect of oil prices when this elasticity is low. Moreover, the fall in industrial production is also steeper and more persistent.

Figure 16: Oil-specific shocks and the long-run elasticity of oil supply



Grey: $\sigma_{SR} = 0.01$ *;* $\sigma_{LR} = 0.45$
Red: $\sigma_{SR} = 0.01$ *;* $\sigma_{LR} = 0.01$

One could also use or model to simulate the effect of any shift in commodity demand, for example in the context of the transition towards a greener economy. In this context, the transition cost – measure in terms of the fall in industrial production – should decrease with the value of the long-run elasticity.

C.5 Anticipated shocks

Our results are robust to the introduction of anticipated aggregate demand shock. We experiment with an anticipated TFP shock revealed one period in advance that is added to the four shocks we considered in our baseline analysis. To identify this shock, we use the first principal component extracted from the prices of a set of non-energy industrial commodities following Alquist et al. (2019). As argued by Kilian and Zhou (2018), this measure can capture anticipations about the future level of economic activity. To allow for other type of shocks affecting the price of metal, we also introduce a metal-specific shock that is similar to the oil demand shock.

This experiment requires us to introduce one additional commodity to the model. This is very easy in our framework: it only requires us to add one additional CES production

function for final good producers, that combines the oil-capital-labor aggregate to a non-energy commodity basket. We assume that supply is fixed (we cannot easily observe supply for an aggregated basket of commodities), we set the income elasticity of demand to one (for simplicity) and estimate the price elasticity of demand. We also assume that these commodities are storable, which is crucial for anticipated shocks to affect the current price of these commodities. We thus estimate the storage demand elasticity to the expected change in non-energy commodity prices.

We find that anticipated demand shocks matter: they are even larger than the unanticipated shocks. However, it does not affect the relative contribution of demand and supply shocks. The main finding of this paper – that the long-run elasticity of oil supply matters – is also robust.

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