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THE TIME VARYING EFFECT OF OIL PRICE SHOCKS ON EURO-AREA EXPORTS

by Marianna Riggi* and Fabrizio Venditti**

Abstract

In this paper we provide novel evidence on changes in the relationship between the real price of oil and real exports in the euro area. By combining robust predictions on the sign of the impulse responses obtained from a theoretical model with restrictions on the slope of the oil demand and oil supply curves, we identify oil supply and foreign productivity shocks in a time varying VAR with stochastic volatility. We find that from the 1980s onwards the relationship between oil prices and euro area exports has become less negative conditional on oil supply shortfalls and more positive conditional on foreign productivity shocks. Using the theoretical model we show that our empirical findings can be accounted for by (i) stronger trade relationship between the euro area and emerging economies (ii) a decrease in the share of oil in production and (iii) increased competitive pressures in the product market.

JEL Classification: C32, E3, F14.
Keywords: oil prices, VAR time-varying parameters, exports.

Contents

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1 Introduction[1]

The evolving relationship between the price of oil and the macroeconomy has been at the center of a lively debate in the empirical literature. A number of studies have indeed documented a decline in the importance of energy price shocks for economic activity, arguing that this relationship has changed around the mid-Eighties (Hooker, 1999, Edelstein and Kilian, 2009 and Blanchard and Galì, 2010).

According to some of these papers, changes in the structure of the economies and in the conduct of monetary policy have progressively insulated advanced economies from the negative effects of energy price increases. Blanchard and Galì (2010) and Blanchard and Riggi (2013), for instance, point to more effective monetary policy, to a fall in the share of oil in both production and consumption and to lower real wage rigidities as plausible causes for this structural break. Other studies argue that the change in the relationship between oil prices and the macroeconomy reflects an evolution in the composition of the shocks underlying oil price fluctuations. According to this literature the role of exogenous flow supply shocks to crude oil, whose effect on economic activity is unambiguously depressive, has only a marginal role in determining oil price fluctuations. In contrast, shocks to the demand for oil associated with global activity booms have been responsible for most increases in the real price of oil from the mid-Seventies onwards (Kilian 2009). This alone could explain why oil price increases are not necessarily associated with recessions. For example, results in Kilian and Hicks (2013) and Aastveit et al (2013) suggest that the surge in the real price of oil observed in the 2000s can be mainly related to the rapid growth in emerging economies.

A natural corollary of this latter view is that, for oil importing countries, the *external* channel could be as relevant as the *domestic* one in understanding the effects of oil price shocks on macroeconomic activity. As booming economies lift the real price of oil they also stimulate *trade* and *exports*, which, in turn, could more than offset the adverse impact of higher energy prices on domestic demand components. Moreover, this mechanism is likely to have been reinforced by the remarkable increase in trade integration favoured by globalization. Considering, for instance, the euro area economy taken as a whole, which is the focus of the present study, between 1970 and 2010 the rate of growth of real

[1]We thank participants to the 4th International Conference in memory of Carlo Giannini held in Pavia in March 2014, and to the International Association for Applied Econometrics conference held in London in June 2014 for their useful comments. The views expressed in the article are those of the authors and do not involve the responsibility of the Bank of Italy. Corresponding author: Marianna Riggi, Economic Outlook and Monetary Policy Directorate. E-mail: marianna.riggi[at]bancaditalia.it

exports has significantly outpaced that of GDP, see Figure 1. As a consequence the share of exports on GDP as well as the relevance of foreign demand fluctuations for domestic growth have constantly increased over time and foreign demand has become more and more important for domestic growth.

Interestingly, however, while the reaction of domestic demand to energy price shocks has been extensively studied, the relationship between trade and oil price fluctuations has been largely overlooked in the literature.[2] Our paper contributes to filling this gap. We start our investigation by looking at simple correlations between euro-area exports and the real price of oil. This preliminary analysis reveals a change in the co-movement between the two variables. In particular, while in the Seventies the correlation between euro-area exports and the real price of oil was basically nil, since the mid-Eighties it has become positive and significantly different from zero. This change might simply reflect an increase in the relative importance of expansionary global shocks (which stimulate both oil demand and global trade) in accounting for oil price variability in more recent periods. This hypothesis is supported, for instance, by findings in Kilian (2009) and Baumeister and Peersman (2013b). A complementary explanation, which constitutes the focus of our paper, is that, conditional on each shock, the relationship between the price of oil and euro-area exports has varied over time owing to some structural changes that have influenced the joint dynamics of the two macroeconomic variables. We investigate the plausible structural sources of such a change using both a theoretical model and a Bayesian time-varying parameter structural vector autoregression with stochastic volatility (TVP-VAR). The theoretical framework is used to model the interplay between the oil market and exports and pick out the robust features of the impact responses of a number of endogenous variables to two structural shocks. The former is a flow oil supply shock, capturing the effect of an unexpected disruption in the production of oil. The latter is a foreign (from the euro area point of view) productivity shock that drives up the demand for oil. Simulations of the theoretical model provide us with useful restrictions on the signs of the reaction of the variables of interest to these shocks. In the spirit of Kilian and Murphy (2014) we combine these restrictions with plausible bounds on the price elasticity of oil supply and on the price elasticity of oil demand to identify these two shocks in the TVP-VAR, and analyze empirically how their effects on euro area exports has evolved over time. The structural analysis conducted on the basis of the TVP-VAR reveals that, conditional on each shock, the co-movement between the real price of oil

[2] One exception is Kilian et al. (2009), whose focus, however, is on the the impact on the external balance of oil price shocks.

price and euro area exports has indeed varied over time. In particular, conditional on negative oil supply shocks the association between the real price of oil and exports has become less negative, while, following a foreign productivity shock, a stronger positive co-movement has emerged.

We finally try to rationalize these changes using our theoretical model. We focus on a number of channels. First, a stronger trade relationship with emerging countries, whose growth has recently driven oil price increases. Second, a fall in the quantitative importance of oil in the world economy. Third, an increase in competitive pressures in the product market. Model simulations suggest that, in combination, these factors could potentially account for the changes documented by our empirical analysis.

The rest of the paper is organized as follows. Section 2 presents the basic stylized facts that motivate our analysis. Section 3 lays out the theoretical model and presents its predictions on the response of some endogenous variables to oil supply and demand shocks. Section 4 describes the empirical evidence obtained from the VAR with time varying coefficients and stochastic volatility. Section 5 uses the theoretical model in order to assess the potential for the three hypotheses listed above to explain our empirical findings. Section 6 concludes.

2 Motivation

We start our investigation by looking at raw correlations between real exports and the real price of oil. Real exports are chain linked export volumes, as measured in the euro area quarterly national accounts. The real price of oil is obtained by first converting in euros the U.S. dollar price of crude Brent, then deflating the resulting nominal price (denominated in euros) by the euro-area consumption deflator.[3] We use data between the second quarter of 1970 and the fourth quarter of 2013 and take log changes of both variables. Table 1 shows the correlation coefficients between these variables in two selected sub-samples. The former runs between 1970 to 1984, the latter between 1985 and 2013. The choice of the cutoff date (1984) is motivated by the findings in Hooker (1999), Edelstein and Kilian (2009) and Blanchard and Galì (2010) who identify a break in the relationship between the real price of oil and economic activity around the mid-Eighties, both for the U.S.

[3]For the years prior to the Monetary Union an estimate of the exchange rate between the euro and the U.S. dollar, as well as of the consumption deflator and of real exports, is provided by the ECB Area Wide Model.

and for the largest euro-area economies.[4] In the first sub-sample no clear co-movement emerges between real exports and the real price of oil, as the correlation coefficient stands at 0.12 and it is not significantly different from zero. In the second part of the sample, instead, a strong positive correlation (0.44) emerges. To further investigate changes in the relationship between these two variables, we run a regression of the rate of growth of real exports on the rate of growth of the real price of oil, allowing for the coefficient of the latter to change at a given point in time. First, we use a dummy variable that equals 0 between 1970 and 1984 and 1 thereafter, and interact it with the real price of oil. The results of this exercise are reported in the first two columns of Table 2. Between 1970 and 1984 the regression coefficient of the real price of oil is estimated at 0.07, and is not significantly different from zero. Its interaction with the shift dummy, on the other hand, displays a coefficient of 0.16, and is significantly different from zero at the 10 percent confidence level, indicating a stronger positive association between export and oil price growth after 1984. Columns 3 and 4 report the results of a similar exercise conducted using a dummy indicator that takes a value of 1 after 1989. The outcome is broadly similar, with the regression coefficient turning from 0.10 before 1989 to 0.15 after that year. Again, the interaction of the shift dummy and the real price of oil results in a coefficient that is significantly different from zero at conventional confidence levels.

In summary this preliminary exploration of the data indicates that a significant change in the reduced form relationship between the real price of oil and euro-area exports has occurred around the second half of the Eighties. In the next section we turn to a structural theoretical model that will provide us with some guidance for a deeper structural analysis of this issue.

3 The theoretical model

Our model is a variant of Clarida, Galì and Gertler (2002), extended to consider the role of oil price dynamics in the spirit of Campolmi (2008) and Lipinska and Millard (2012). In our economy there are two oil importing countries, home (H) and foreign (F). They differ in size and share identical preferences, technology and market structure, though shocks may be imperfectly correlated. H has a mass of households n, whereas F has a mass $(1-n)$. In each country, production takes place in two stages. There is a

[4] We do not rely on formal break tests to date the change in the regression coefficients since these tests have been shown to have very low power in detecting time variation when the parameters of the true data generating process behave as a random walk (Benati, 2007).

continuum of intermediate goods firms each producing a differentiated input. These firms are monopolistic competitors and set nominal prices in a staggered fashion. Final goods producers are perfectly competitive. They combine intermediate inputs into final output, which they sell to households. The number of final goods firms within each country equals the number of households, whereas the number of intermediate goods firms is normalized at unity in each country[5]. Oil is used by the intermediate firms in the two countries, H and F, as an input in production together with employment. Within each economy households consume a domestically produced good and a good imported from the other country. In both countries households have access to a complete set of Arrow-Debreu securities which can be traded both domestically and internationally. An oil exporting country sells its endowment of oil and spends the associate revenues on consumption of goods from both H and F. Oil price is determined in equilibrium.

We make two assumptions about the oil market. First, oil is non-storable. This is clearly an ad-hoc hypothesis - as oil is in fact a storable commodity - made on the ground of simplicity and shared by most business cycle models dealing with the macroeconomic effects of oil shocks (Blanchard and Galì 2010, Campolmi 2008, Lipinska and Millard 2012, among many others). According to this strand of literature the price of oil is largely determined by the movements in the amount of oil being consumed relative to that being supplied, with little role given to inventories. Kilian and Murphy (2014) were the first to prove the importance of changes in desired stocks in determining the price of oil. They explicitly allow for shocks to the speculative demand for oil, identified in a structural VAR using data on oil inventories and drawing on insights from the economic theory for storable commodities. They find that speculating trading does not explain the surge in the real price of oil between 2003 and 2008, but played a role in the oil price's behavior of 1979, 1986 and 1990-91. A recent contribution by Unalmis et al. (2012) incorporates speculative oil storage into a general equilibrium framework, giving rise to a dynamic link among oil inventories, storers' expectations of oil price and the spot price. In this model, a storage demand shock, which could be interpreted as precautionary demand shock, leads to an increase in storage, a drop in the availability of oil and an increase in the real price of oil. Accordingly, disregarding the storage facility in the estimated model causes a considerable upward bias in the estimated role of oil supply shocks in driving oil price fluctuations.

The second simplifying assumption is the exogeneity of oil supply. This assumption has

[5] As shown by Clarida, Gali and Gertler (2002) this assumption ensures that final goods producers face the same technology.

some grounding in the empirical literature, where there is wide agreement that the price elasticity of oil supply is indeed close to zero (Hamilton, 2009). This is because changing oil production is highly costly and, given the uncertainty about the state of the crude oil market, oil producers do not revise the production level in response to high-frequency changes in demand (Kilian, 2009).[6] This assumption is maintained by a large part of the theoretical literature (see Campolmi 2008; Lipinska and Millard 2012; Unalmis et al 2012). Some recent work, however, has shown that a mildly positively sloped short-run supply curve is indeed consistent with historical evidence (Kilian and Murphy, 2014). To take into account these recent developments, in the empirical section we relax this assumption and allow for a mildly upward sloping supply curve, using the elasticity bounds estimated by Kilian and Murphy (2014).

Given our objectives, we focus on two sources of cyclical fluctuations driving up oil prices: an oil supply shrinkage and an increase in foreign productivity. The latter is meant to capture the dynamic effects of an oil demand increase fostered by faster foreign growth.

3.1 Preferences

The representative household i in country H maximizes:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{(C_t(i) - hC_{t-1})^{1-\sigma}}{1-\sigma} - \frac{N_t(i)^{1+\phi}}{1+\phi} \right\} \tag{1}$$

where β is the discount factor, N_t denotes the household's i hours of labor and $C_t \equiv \Theta C_{F,t}^{\gamma} C_{H,t}^{1-\gamma}$ is a composite index of consumption of home and foreign goods, with $\Theta \equiv \gamma^{-\gamma} (1-\gamma)^{-(1-\gamma)}$. $C_{F,t}$ is an index of consumption of imported goods produced by F, $C_{H,t}$ is an index of consumption of domestic goods and $\gamma \equiv (1-n)\chi$ denotes the weight of imported goods in the consumption basket of households located in country H. The latter depends on the relative size of F and on χ, which is the degree of trade openness of H.

Households are concerned with "catching up with the Joneses": there is a certain degree of external habit persistence $h \in [0,1)$; C_{t-1} is the aggregate consumption level in period $t-1$. The period budget constraint is given by

$$P_{H,t}C_{H,t} + P_{F,t}C_{F,t} + Q_t^B B_t = B_{t-1} + W_{H,t}N_t + \Pi_t$$

[6] Note, however, that our assumption is stronger than in Kilian (2009), who only imposes a one month vertical oil supply curve.

where $P_{H,t}$ is the domestic price index, $P_{F,t}$ is a price index for foreign goods (in domestic currency), $W_{H,t}$ is the nominal wage, Π_t are profits, Q_t^B is the price of a one-period nominally riskless bond, paying one unit of domestic currency and B_t denotes the quantity of that asset purchased in period t. The optimal allocation of expenditures between imported and domestically produced goods implies $P_{H,t}C_{H,t} = (1-\gamma) P_t C_t$ and $P_{F,t}C_{F,t} = \gamma P_t C_t$, where $P_t = P_{H,t}^{1-\gamma} P_{F,t}^{\gamma}$ is the consumer price index. In an analogous manner, the composite index of consumption in the foreign economy is $C_t^* \equiv \Theta^* \left(C_{F,t}^*\right)^{1-\gamma^*} \left(C_{H,t}^*\right)^{\gamma^*}$, where $\gamma^* \equiv n\chi^*$ and χ^* is the degree of trade openness in F.[7] The optimal allocation of expenditures implies $P_{H,t}^* C_{H,t}^* = \gamma^* P_t^* C_t^*$ and $P_{F,t}^* C_{F,t}^* = (1-\gamma^*) P_t^* C_t^*$, where $P_{F,t}^*$ denotes the price of foreign goods denominated in the producer's currency, $P_{H,t}^*$ denotes the price of domestic goods denominated in the foreign currency and P_t^* is the consumer price index in F denominated in foreign currency $P_t^* = P_{H,t}^{*\gamma^*} P_{F,t}^{*(1-\gamma^*)}$.

The law of one price implies that $P_{F,t} = \mathcal{E}_t P_{F,t}^*$, where $\mathcal{E}_t$ is the nominal exchange rate. The real exchange rate R_t is defined by $R_t \equiv \frac{\mathcal{E}_t P_t^*}{P_t}$.

3.2 Risk sharing

Under complete markets, the efficiency conditions for bonds' holdings by residents in F reads:

$$Q_t^B = \beta \mathbb{E}_t \frac{P_t^* \mathcal{E}_t}{P_{t+1}^* \mathcal{E}_{t+1}} \frac{\left(C_t^* - hC_{t-1}^*\right)^{\sigma}}{\left(C_{t+1}^* - hC_t^*\right)^{\sigma}} \tag{2}$$

Equating (2) with the Euler equations for both the home and foreign economies and log-linearizing around the steady state yields the familiar expression for the wedge between domestic and foreign interest rates:

$$i_t - i_t^* = \mathbb{E}_t \left[\pi_{t+1} - \pi_{t+1}^*\right] - r_t + r_{t+1} \tag{3}$$

where we have denoted with r the proportional deviation from steady state of the real exchange rate and with π and π^* the CPI inflation rate in H and F, respectively.

[7] The absence of home bias would require that the weight of domestically produced goods in home consumption basket $(1-\gamma)$ is equal to the weight of imported goods in foreign consumption basket (γ^*); home bias in consumption would require that $(1-\gamma) = 1 - (1-n)\chi > \gamma^* = n\chi^*$.

3.3 Firms

Final goods producers are perfectly competitive. Each of them produces output by using a continuum of intermediate goods as input, according to the CES technology $Y_t = \left(\int_0^1 Y_t(f)^{\frac{\epsilon-1}{\epsilon}} df \right)^{\frac{\epsilon}{\epsilon-1}}$ where Y_t denotes aggregate output and $Y_t(f)$ is the input produced by intermediate goods firm f. Both variables are expressed in per capita terms. Profit maximization, taking the price of the final good $P_{H,t}$ as given, implies the set of demand equations $Y_t(f) = \left(\frac{P_{H,t}(f)}{P_{H,t}}\right)^{-\epsilon} Y_t$ and the domestic price index $P_{H,t} = \left(\int_0^1 P_{H,t}(f)^{1-\epsilon} df \right)^{\frac{1}{1-\epsilon}}$.

Intermediate goods firms are monopolistic competitors, produce a differentiated intermediate good and set nominal prices in a staggered fashion. Each of them produces with the following technology:

$$Y_t(f) = N_t(f)^{\alpha_n} M_{H,t}(f)^{\alpha_m} \tag{4}$$

where $M_{H,t}(f)$ is oil used by firm f and $N_t(f)$ is labor input used by firm f (both normalized by population size). Firms take the price of both inputs as given. Accordingly, cost minimization implies $\frac{M_t^H(f)}{N_t(f)} = \frac{\alpha_m}{\alpha_n} \frac{W_{H,t}}{P_{m,t}}$, where $P_{m,t}$ is the nominal price of oil. Firm's f's nominal marginal cost is given by $\Psi_t(f) = \frac{W_{H,t}}{\alpha_n (Y_t(f)/N_t(f))} = \frac{P_{m,t}}{\alpha_m (Y_t(f)/M_{Ht}(f))}$. Following the formalism of Calvo (1983), each period only a fraction of intermediate goods firms $(1-\theta)$, selected randomly, reset prices. The remaining firms keep their prices unchanged.

Intermediate goods firms in country F produce with the following technology:

$$Y_t^*(f) = A_t^* N_t^*(f)^{\alpha_n} M_{F,t}(f)^{\alpha_m} \tag{5}$$

where A_t^* is a productivity factor common across firms. We assume a first order autoregressive process $A_t^* = \left(A_{t-1}^*\right)^{\rho_A} e^{u_t^a}$, where u_t^a is an i.i.d. shock to foreign technology level.

3.4 Oil market

As in Lipinska and Millard (2012), oil is costless to transport and is non storable. Oil producer does not have access to world capital markets and simply uses the revenues from its production of oil to purchase final goods produced by H and F. The representative consumer in the oil producing country maximizes the following utility:

$$\max \mathbb{E}_t \sum_{r=0}^{\infty} \beta^r C^O_{t+r}$$

Aggregate consumption $C_t^O \equiv \Gamma \left(C^O_{F,t}\right)^{\varpi_O} \left(C^O_{H,t}\right)^{1-\varpi_O}$ is a composite consumption index of goods produced by H and F, where $\Gamma \equiv \varpi_O^{-\varpi_O} \left(1-\varpi_O\right)^{-(1-\varpi_O)}$, ϖ_O is the share of F-produced goods in the consumer's basket, $C^O_{H,t}$ is the consumption of the H-produced goods and $C^O_{F,t}$ is the consumption of F-produced goods. The consumer's budget constraint is given by $P_{m,t}M_t^s = C^O_{H,t}P_{H,t} + C^O_{F,t}P_{F,t}$, where M_t^s is oil endowment as defined below. Oil demand of the world economy is:

$$M_t^d = n\int_0^1 M_{H,t}(i)\,di + (1-n)\int_0^1 M_{F,t}(i)\,di = \frac{\alpha_m}{\alpha_n}\left(n\frac{W_{Ht}}{P_{m,t}}N_t + (1-n)\frac{W^*_{Ft}}{P^*_{m,t}}N^*_t\right) \quad (6)$$

The oil endowment M_t^s is assumed to follow a first order autoregressive process $M_t^s = \left(M_{t-1}^s\right)^{\rho_m} e^{u_t^m}$, where u_t^m is an i.i.d. shock to oil supply. Equilibrium in the oil market requires:

$$P_{m,t} = \frac{\alpha_m}{\alpha_n}\left(\frac{nW_{Ht}N_t + (1-n)\,W_{Ft}N_t^*}{M_t^s}\right) \quad (7)$$

3.5 Aggregate resource constraint

We can write the aggregate resource constraint in home and foreign country as follows:

$$nY_t = nC_{H,t} + (1-n)C^*_{H,t} + C^O_{H,t} \quad (8)$$

$$(1-n)Y_t^* = (1-n)C^*_{F,t} + nC_{F,t} + C^O_{F,t} \quad (9)$$

3.6 Monetary policy

We assume that the central bank of the home economy follows an interest rate rule:

$$I_t = \left[(\pi_t)^{\phi_\pi}(Y_t)^{\phi_x}\right] \quad (10)$$

where $I_t \equiv 1 + i_t$ is the nominal interest rate. A symmetric rule is assumed for F. Steady state relations and optimality conditions are shown in Appendix A.

3.7 Model consistent impact sign restrictions

We use our theoretical frame to pick out the robust features of the responses of some endogenous variables to the two random disturbances in the model. We follow Canova and Paustian (2011), Dedola and Neri (2007) and Lippi and Nobili (2012) and carry out a Monte Carlo simulation on the relevant parameters of our theoretical model, assuming that they are uniformly and independently distributed over wide ranges. In particular, we draw 10000 vectors of the structural parameters from the uniform densities reported in Table 3, for each draw we save the responses to an oil supply shock and to a foreign productivity shock and compute the median, the 5th and 95th percentiles of the resulting distribution of impulse responses.

Table 3 reports the ranges of the uniform distributions for the parameters of the model that are simulated and the values imposed on the remaining calibrated parameters. Concerning the former group, the ranges of the uniform densities are sufficiently wide so as to cover all the reasonable values that these parameters can take. The degree of price stickiness is drawn over the interval that includes both a flexible prices' scenario (when $\theta = 0.1$ firms adjust their prices each quarter) and an almost completely rigid prices' scenario (when $\theta = 0.95$ firms adjust their prices once every twenty quarters). The parameter capturing the degree of habits is drawn from the range over which it is theoretically defined $h \in [0, 1)$. The ranges for the degree of trade openness in H and F include, at one extreme, the possibility that the country is completely closed to foreign trade (when χ and $\chi^* = 0$) and, at the other extreme, a high degree of trade openness (when χ and $\chi^* = 1$) and the possibility of no home bias in consumption. The share of foreign goods in the oil exporter country's consumers' basket is drawn from a uniform density over the support between $\varpi_O = 0$ (implying that oil exporters consume only $H-$produced goods) and $\varpi_O = 1$ (implying that oil exporters consume only $F-$produced goods). The ranges from which the coefficients of the Taylor rule and the inverse of Frisch elasticity are drawn encompass most calibrated and also estimated values used in the literature: $\phi_\pi \in [1.1, 5]$, $\phi_x \in [0, 1]$ and $\phi \in [0.1, 2]$. The elasticity of substitution among differentiated goods ϵ is drawn over the interval between 3 (implying a desired markup of 50%) and 11 (implying a desired markup of 10%). The range for the share of oil in production α_m is $[0.01, 0.04]$. The latter encompass the plausible values according to our computations based on OECD input output tables. As for the serial correlation of the shock processes, we consider the same support used in Lippi and Nobili (2012), namely any value between and including 0.5 and 0.999, thus allowing also for near-random walks.

The remaining four parameters are calibrated. We set the discount factor in line with standard calibrations of DSGE models ($\beta = 0.998$). By calibrating $n = 0.5$ we assume that F and H have the same size. We set the risk aversion $\sigma = 0.1$, consistently with long lasting effects of shocks. In line with standard practice, we calibrate the elasticity of output with respect to labor input α_n to a value of 2/3.

The results of the model simulations are shown in Figures 2 and 3 , where we report the impulse responses of the four variables that we will use in the empirical analysis: the real price of oil, real exports of the home country, foreign output and global oil production to the two structural shocks. A feature common to these responses is that they can revert to steady state more or less slowly, given rather uninformative densities over the persistence of shocks ρ_m and ρ_a.

Figure 2 shows the effects of an oil supply shock, normalized to yield a 10 percent reduction in oil production on impact. The results fit well the conventional wisdom about the implications of an oil supply shortfall: the real price of oil increases and foreign GDP declines persistently. The response of exports of the home country H is mostly negative, although, for some combination of the model parameters, a positive response can not be ruled out. Figure 3 illustrates the impulse responses to a positive productivity innovation in the foreign country, F. The real price of oil goes up, as the demand for oil increases, and exports rise benefiting from the foreign expansion. Our theoretical model is silent on the implications of this shock on oil production, because, as discussed above, it makes the assumption of a vertical oil supply curve.

In the next section, these qualitative indications will provide a starting point for disentangling empirically two structural sources of fluctuations in oil prices: oil supply shocks and oil demand increases driven by foreign productivity shocks.

4 Empirical evidence

We jointly model four variables: the real price of oil, real exports, foreign GPD, and the global production of crude oil. The definition of real exports and of the real price of oil has been provided in Section 2. To construct a measure of foreign GDP we follow Hahn and Mestre (2011) and aggregate GDP volumes (at the price levels and PPP of 2000) from all available countries, excluding euro area economies. Further details are provided in Appendix B. Finally, global oil production is measured by the world production of crude oil (quarterly average of barrels per day). All variables are in log-changes. When information is available at the monthly frequency (like for the nominal price of oil and for oil production), it is aggregated at the quarterly frequency by taking quarterly averages.

Foreign GDP is constructed from annual data and interpolated at the quarterly frequency using the Chow-Lin methodology. The sample period runs from the second quarter of 1970 to the fourth quarter of 2013. In Appendix B we provide further details on data sources and transformations.

4.1 The model

We specify the following VAR(p) model:

$$y_t = B_{0,t} + B_{1,t} y_{t-1} + B_{2,t} y_{t-2} + ... + B_{p,t} y_{t-p} + u_t, \qquad u_t \sim N(0, \Sigma_t)$$

We stack the VAR coefficients in the vector $\theta_t = vec([B_{0,t}, B_{1,t}, B_{2,t}, ..., B_{p,t}]')$ and assume that they evolve according to the law of motion $p(\theta_t/\theta_{t-1}, Q) = \mathbb{I}(\theta_t) f(\theta_t/\theta_{t-1,}Q)$, where the indicator function $\mathbb{I}(\theta_t)$ rejects unstable draws and the function $f(\cdot)$ is a multivariate Gaussian distribution such that, conditional on past information, θ_t is normally distributed with mean θ_{t-1} and variance Q. Based on these assumptions the VAR has the following state space representation:

$$\begin{aligned} \underset{n\times 1}{y_t} &= (I_n \otimes x_t)\, \theta_t + u_t, \qquad & u_t \sim N(0, \Sigma_t) \\ \theta_t &= \theta_{t-1} + \epsilon_t, & \epsilon_t \sim N(0, Q) \end{aligned} \tag{11}$$

where the row vector $x_t = [1, y'_{t-1}, y'_{t-2}, \ldots, y'_{t-p}]$ collects the intercept and the lags of the endogenous variables. In line with the literature we set $p = 2$. The VAR's reduced form innovations in (11) follow a multivariate Gaussian with zero mean and time varying covariance matrix Σ_t. The matrix Σ_t is further partitioned as $\Sigma_t = A_t^{-1} H_t A_t^{-1\prime}$, where A_t is a lower triangular matrix with ones on the main diagonal, and H_t is a diagonal matrix, that is:

$$A_t = \begin{bmatrix} 1 & 0 & 0 & 0 \\ \alpha_{21,t} & 1 & 0 & 0 \\ \alpha_{31,t} & \alpha_{32,t} & 1 & 0 \\ \alpha_{41,t} & \alpha_{42,t} & \alpha_{43,t} & 1 \end{bmatrix}, \quad H_t = \begin{bmatrix} h_{1,t} & 0 & 0 & 0 \\ 0 & h_{2,t} & 0 & 0 \\ 0 & 0 & h_{3,t} & 0 \\ 0 & 0 & 0 & h_{4,t} \end{bmatrix}$$

Collecting the $n(n-1)/2$ time varying elements of A_t in the vector a_t and the n time varying elements of H_t in the vector h_t, we further assume that:

$$\begin{aligned} a_t &= a_{t-1} + \eta_t, & \eta_t &\sim N(0, \Omega_a) \\ \log(h_t) &= \log(h_{t-1}) + e_t, & e_t &\sim N(0, \Omega_h) \end{aligned}$$

The structure of the covariance matrices Ω_a and Ω_h is the following:

$$\Omega_a = \begin{bmatrix} S_1 & 0_{1\times 2} & 0_{1\times 3} \\ 0_{2\times 1} & S_2 & 0_{2\times 3} \\ 0_{3\times 1} & 0_{3\times 2} & S_3 \end{bmatrix}, \quad \Omega_h = \begin{bmatrix} \sigma_1 & 0 & 0 & 0 \\ 0 & \sigma_2 & 0 & 0 \\ 0 & 0 & \sigma_3 & 0 \\ 0 & 0 & 0 & \sigma_4 \end{bmatrix}$$

where $S_1 = cov(\eta_t^1), S_2 = cov(\eta_t^2, \eta_t^3)$ and $S_3 = cov(\eta_t^4, \eta_t^5, \eta_t^6)$. This implies that the non-zero non-unit elements of A_t are independently distributed across rows, while being correlated within rows. Block independence is assumed for the random errors, so that their joint distribution is:

$$\begin{bmatrix} \varepsilon_t \\ \epsilon_t \\ \eta_t \\ e_t \end{bmatrix} \sim N(0, V), \quad V = \begin{bmatrix} I_4 & 0 & 0 & 0 \\ 0 & Q & 0 & 0 \\ 0 & 0 & \Omega_a & 0 \\ 0 & 0 & 0 & \Omega_h \end{bmatrix}$$

where $\varepsilon_t = A_t^{-1} H_t^{1/2} u_t$. The model is estimated with Bayesian methods, through a Gibbs sampling algorithm. The exact steps of the algorithm are described in details in a number of papers (see for example Benati and Mumtaz, 2007, pages 9 to 12) and therefore will not be repeated here. Further details on the application of the method to our specific case are provided in Appendix B.

4.2 Identification of the structural shocks

Orthogonal structural shocks ε_t are recovered from the reduced form residuals u_t through the following relationship:

$$u_t = A_{0,t}\varepsilon_t, \qquad \varepsilon_t \sim N(0, I_n) \tag{12}$$

so that $\Sigma_t = A_{0,t}A'_{0,t}$. Consistently with the theoretical model laid out in Section 3, we identify two structural shocks, namely a disturbance to the supply of oil and a foreign (from the euro area point of view) productivity shock. To disentangle these two shocks we follow Baumeister and Peersman (2013a) and Baumeister and Peersman (2013b) but complement their approach with insights from Kilian and Murphy (2014). In more details, we employ a mix of restrictions on the signs of the first two columns of the structural impact matrix $A_{0,t}$ as well as on the relative magnitude of some of its elements, so as to ensure that the slopes of the oil demand and of the oil supply curve have the correct sign and fall within plausible values. Furthermore, we add to these two sets of restrictions a constraint on the dynamic response of the real price of oil conditional on a supply shock. The procedure to identify the structural shocks is based on the algorithm proposed by Rubio-Ramirez, Waggoner and Zha (2010), modified to take into account the additional constraints.

4.2.1 Sign restrictions on impact

The theoretical model provides us with a set of robust restrictions on the sign of the response of the variables included in our VAR to both a negative shock to the supply of oil and to a positive foreign productivity shock.

Following an unexpected disruption in oil supply the real price of oil increases, while oil production and foreign output decrease on impact. The response of euro area exports is very likely to be negative, yet given some uncertainty in the sign of the response produced by the DSGE model we prefer no to impose any sign on the impact response of this variable.

In response to a foreign productivity shock, which stimulates both the demand for oil and for euro area goods, the real price of oil, euro area exports and foreign output unambiguously increase. Regarding oil production, our theoretical model would imply a zero response on impact, consistently with assumptions in Kilian (2009). Kilan and Murphy (2014) challenge the hypothesis of a vertical short-term supply curve and allow for a positively sloped supply schedule, but impose a tight upper bound on the impact price elasticity of oil supply. In our empirical investigation we follow their indications and constrain the response of oil supply to be non-negative on impact, an assumption consistent both with a vertical (like in the theoretical model) and with a positively sloped supply curve in the short term. A summary of the identifying impact sign restrictions is reported in Table 4.

Even when they are derived from a theoretical model, impact sign restrictions have been shown to be too weak to provide reasonable estimates of the effects of oil demand and oil supply shocks. Kilian and Murphy (2012, 2014) suggest to further narrow down the set of admissible structural models by imposing both dynamic sign restrictions and elasticity bounds. In the remaining sub-sections we explain the additional identifying restrictions that we impose to reduce the set of admissible structural impact matrices $A_{0,t}$.

4.2.2 Dynamic sign restrictions

Following Kilian and Murphy (2014) we restrict the response of the real price of oil to an oil supply shock to be positive for at least five quarters (starting in the impact period) after the initial shock.

4.2.3 Elasticity bounds

We further reduce the set of admissible structural impact matrices $A_{0,t}$ through restrictions on the price elasticity of oil supply and of oil demand.

Starting from the oil supply curve, an estimate of the impact price elasticity can be obtained from the ratio of the response of oil production relative to the response of the real price of oil to an oil demand shock, which in our theoretical model corresponds to an unexpected change in foreign TFP. Kilian and Murphy (2014) argue that a plausible upper bound to such elasticity (which is required to be non-negative) stands at 0.025. This estimate corresponds to the ratio of the percentage increase in oil supply and the percentage increase in the real price of oil observed in August 1990, when the First Gulf War burst out. Since the spike in the price of oil recorded in this particular occasion can be seen as truly exogenous, the corresponding change in the production of oil traces the price elasticity of supply. In their study Kilian and Murphy find that their findings are robust to higher values of this bound, up to 0.1. In our analysis we pick the higher end of the [0.025-0.1] range considered by these authors for two reasons. First, we use quarterly, rather than monthly data and it is therefore reasonable to assume that, at this lower frequency, producers have more opportunity to change supply in response to demand disturbances. Second, and more importantly, we measure oil prices in euros. Since an increase in the nominal price of oil in U.S. dollars is historically accompanied by a depreciation of the U.S. dollar[8], the sensitiveness to structural shocks of the nominal price of oil is likely to

[8] In our dataset, between the second quarter of 1970 and the fourth quarter of 2013, we observe an unconditional correlation of -0.4 between the price of oil in U.S. dollars and the dollar/euro exchange rate. Kilian (2008) documents a depreciation of the U.S. dollar, following an oil price increase driven by

be lower when the latter is measured in euros, therefore requiring an upward adjustment of the oil supply elasticity. The magnitude of such adjustment (by a factor of 4, from 0.025 to 0.1) is consistent with the fact that the standard deviation of the percentage change in the U.S. dollars nominal price of oil is around four times as high as the one computed on the nominal price of oil in euros (22.5 as opposed to 4.5). Given the ordering of the variables (real price of oil, exports, foreign GDP and oil production) and of the shocks (oil supply shock first, oil demand shock second), the oil supply elasticity bound, together with the sign restriction described above, implies the following constraint on the admissible structural matrix $A_{0,t}$: $0 \leq A_{0,t}^{(4,2)}/A_{0,t}^{(1,2)} \leq 0.1$.

Next, we turn to the price elasticity of demand (which can be inferred by the ratio of the impact response of oil production to an oil supply shock relative to the impact response of the real price of oil). Plausible values for this elasticity can be inferred from Kilian and Murphy (2014) and Baumeister and Peersman (2013b). When imposing a price elasticity of supply of 0.1, Kilian and Murphy (2014) find an impact oil demand elasticity between -0.24 and -0.76 with 64 percent confidence.[9] A similar range of values is reported by Baumeister and Peersman (2013b). Using a VAR with time varying parameters, they estimate the oil demand elasticity to have declined in absolute value from -0.6 to -0.1 in the past four decades. Taking into account this evidence we rule out structural impact matrices $A_{0,t}$ that yield an impact elasticity of demand more negative than -0.8. Taking also into account the impact sign restrictions discussed above, we require the elements of $A_{0,t}$ to satisfy these set of inequalities $0 \geq A_{0,t}^{(4,1)}/A_{0,t}^{(1,1)} \geq -0.8$ for $A_{0,t}$ to be in the set of admissible structural models.

4.2.4 The algorithm

To summarize, the identification procedure consists of the following steps.

1. Obtain a draw of the reduced form parameters $\widetilde{\theta}_t$ and $\widetilde{\Sigma}_t$ from the posterior distribution.

2. Let $\widetilde{\Sigma}_t = P_t D_t P_t'$ be the eigenvalue-eigenvector decomposition of the covariance matrix at time t.

an exogenous oil supply shock.

[9] See Table II in Kilian and Murphy (2014). The model analyzed in Kilian and Murphy (2014) includes oil inventories. This allows them to distinguish the price elasticity of oil in production from the price elasticity of oil in use, where the latter is by construction lower (in absolute value) due to adjustments in inventories following a supply shock. We do not make such a distinction, implicitely equating production and consumption.

3. Draw an $(n \times n)$ independent standard normal matrix $\overline{X}$ and compute the QR decomposition $\overline{X} = QR$ where $QQ' = I$ and R is a diagonal matrix with positive elements on the main diagonal.

4. Generate a candidate structural impact matrix $A_{0,t} = P_t D_t^{\frac{1}{2}} Q'$ and compute the impulse response functions based on $A_{0,t}$. If the impulse responses satisfy the restrictions described above, record $A_{0,t}$ and the corresponding impulse response functions, otherwise discard them.

We apply the above algorithm until we retain 500 admissible $A_{0,t}$ at each time t.

4.2.5 Summarizing the dynamic effects of structural shocks

When there is more than one structural admissible model, like in our case, summarizing the dynamic effects of structural shocks poses a conceptual challenge. Fry and Pagan (2011), in fact, point out that the conventional choice of reporting the vector of median posterior responses is fundamentally flawed. It is indeed very likely that, at different horizons, the median responses will be generated by different structural models, making it impossible to give the results a structural interpretation. Their suggested solution is to focus on the structural impact matrix $A_{0,t}$ that generates Impulse Response Functions (IRFs) that show minimum distance with respect to the median posterior response. This ensures that the vector of responses is generated by a single structural model that can be seen, in some sense, as the most representative one. However, Inoue and Kilian (2013) criticize this proposal by noticing that the median vector is not a well defined measure of central tendency, so that, even if the strategy proposed by Fry and Pagan (2011) were to result in a perfect match between the IRFs of a single structural model and the median posterior response, there would be no compelling reason to focus on such a model. A practical way to address this shortcoming is to search for a model that minimizes that distance from the mean - rather than from the median - response (see Inoue and Kilian, 2013, for a discussion). This choice has some theoretical appeal given that a quadratic loss function would be minimized at the posterior mean and that the mean is a well defined statistical concept in the case of vectors. We therefore follow this route and represent results from our structural VAR based on the admissible model that minimizes (at each point in time, given the time-varying nature of the model parameters) the distance from the mean response.[10]

[10] A shortcoming of relying on the posterior mean is that there is no way to construct credible sets around the central tendency, as explained in Inoue and Kilian (2013).

4.3 Estimation Results

We start by investigating whether and how the response of euro-area exports to unexpected falls in the production of crude oil and to foreign TFP shocks has changed over time.

In Figure 4 we display the IRFs of exports to the two identified structural shocks. The top panel of this plot shows that, despite the fact that no sign restriction was placed on the impact effect on exports, the response of exports to a shock to the supply of oil is consistently negative throughout the sample. However, an upward tendency can be detected in the profile of the IRFs, so that the effect of the oil supply shock results more negative in the 70s than in the following decades, indicating that euro-area economic activity has been progressively more insulated from the recessionary impact of oil supply disruptions also thanks to a less negative response of foreign sales. In the top panel of Figure 5 we report the same information but average the IRFs over four separate sub-samples, roughly corresponding to the four decades under investigation.[11] The smoother profile of the time varying IRFs magnifies the difference between the 70s and the following decades.

We next turn to the dynamic effect of a structural shock to foreign TFP, shown in the bottom panel of Figures 4. Again, we detect notable time variation in the response of export (constrained to be positive on impact) to an unexpected increase in external demand. The sensitiveness of euro area exports to such a shock has increased smoothly over time, stabilizing around historically high levels after 2000. This gradual increase is all the more evident from the bottom panel of Figure 5.

After having documented an attenuation in the negative effects of oil supply shocks on euro-area exports and an amplification of the positive impact of foreign demand shocks, we now turn to examine changes in the co-movement between exports and the real price of oil conditional on the two identified shocks. Following den Haan and Sumner (2004) we investigate the issue by looking at the conditional covariance between the variables of interest, which can be computed as the product of the response functions at each horizon k, cumulated over the previous horizons.[12]

The estimated conditional covariances between euro-area exports and the real price of oil are shown in Figures 6 for the single quarters, and in 7 for the four decades in our

[11] Since our sample extends to 2013 the fourth sub-sample has 12 observations more than the first three. Excluding these observations does not change the results.

[12] See Kilian (2008) for an application of this methodology to the co-movement of consumer prices and output conditional on exogenous oil supply shocks.

sample. The top panels of these Figures show that, conditional on an oil supply shock, the co-movement between exports and the real price of oil has become markedly less negative over time, especially when the 70s are compared to the following decades. Conditional on a foreign TFP shock, which causes an unexpected increase in oil demand, the covariance between export volumes and the real price of oil has become more positive over time, with a peak at the end the Nineties, early 2000s. Although this tendency has partially reversed in recent years, the covariance is substantially higher at the end of the sample than in the 70s, early 80s.

Summing up, based on a VAR with time varying parameters and stochastic volatilities we have provided evidence of a structural change in the transmission of identified oil supply and oil demand shocks to the joint dynamics of euro-area exports and of the real price of oil. In recent decades oil price increases due to an oil supply disruption have been coupled with a more muted fall of export volumes, while a stronger association between oil price and export increases has emerged conditional on an unexpected surge in global output. These variations in conditional second moments point to the existence of at least some structural changes that have affected the joint dynamics of euro area exports and the real price of oil over last decades.

5 Interpreting structural changes

In this section we use the theoretical model developed in Section 3 to shed light on the plausible mechanisms behind the structural changes uncovered by our empirical analysis. The three plausible explanations, not mutually exclusive, on which we focus are the consolidation of the trade relationship with emerging economies, the decrease in the share of oil in production and lower markups.[13]

[13] We also explored a fourth channel: a new advantageous flood of petrodollars towards the euro area. A surge in oil prices leads to a redistribution of income from oil consuming to oil producing countries and the use that the latter make of their revenues can considerably affect global imbalances and, thus, the overall impact of rising oil prices on oil importing economies. Quantifying how the oil-revenues are spent is somewhat problematic. Still, Higgins et al. (2006) report suggestive evidence that the geography of petrodollar recycling has changed: oil exporters are importing more goods from the euro-area today than they were 25 years ago and fewer goods from the US. We have studied the changes in the responses of exports when $(1-\varpi_O)$, i.e. the parameter capturing the preference of the oil producing economy for goods produced by H, becomes higher. The implications conditional on foreign productivity shocks are negligible. Considering the responses to an oil supply shock, to have a significant change in the response of exports the fraction of petrodollars recycled back home to purchase H- produced goods should have increased from zero to 100%.

5.1 Trade relationship with emerging countries

The stronger is the trade relationship between euro area and emerging countries, the larger will be the positive response of euro area exports to faster growth in emerging economies. A first gauge of the importance of this channel can be gained by looking at the evolution of the shares of exports towards Asian economies in the four largest euro-area countries.

Figure 8 shows that export shares towards Asia have indeed notably increased since the end of the 1980s. This increase is glaring in Germany, and, to a lesser extent, in France, where the share of exports directed to Asian emerging countries has more than tripled over the last two decades, reaching around 10 and 8 percent, respectively, compared to about 6 in Italy and 4 in Spain. The privileged trade relationship with emerging economies might have played an important role in the macroeconomic performance of Germany during the 2000s, when Asia (and more in particular China) progressively became a major sales market for German goods.

Figures 9 and 10, panels A, illustrate the changes in the responses of exports in H to the two different sources of fluctuations in oil prices, when χ^* becomes higher. In the model χ^* is the deep parameter capturing the preference in F for goods produced by H.[14]

When higher oil prices are driven by faster growth in F, the positive conditional correlation between the real price of oil and exports in H can be amplified by a tighter trade relationship with F (Figure 10, panel A). However, this structural change is conducive to larger negative response of exports to oil supply shocks (Figures 9 panel A), an implication of the model that contrasts starkly with the evidence shown in Figure 5.

The rationale is as follows. Oil supply shocks are recessionary for both H and F and thus lead in both countries to a contraction in demand, that involves both consumption of domestic goods and well as consumption of imported goods. Oil supply shocks are instead expansionary for the oil producing economy, that accordingly increases its consumption of both $H-$ and $F-$ produced goods. From the point of view of H, its exports towards F fall while its exports towards the oil producing economy rise. When the share of H-produced goods in the consumption basket of F goes up (i.e. when χ^* rises), all other things held constant, the ratio of exports in H towards F over total exports increases and, at the same time, the ratio of exports in H towards the oil producing country over total exports falls. This explains why, when χ^* rises, the contractionary effects of the oil

[14] Parameters' calibration behind the responses shown in Figures 9 and 10 is consistent with the one used to get sign restrictions in Section 3.7: those parameters that are kept fixed in Section 3.7 are calibrated at the same values as indicated in Table 3; for those parameters that are Monte-Carlo simulated in Section 3.7 we choose a value inside the ranges given in Table 3.

supply shock on exports in H become larger.

5.2 Lower oil shares

Edelstein and Kilian (2009) document that the overall share of energy expenditures in US consumer spending fell steadily throughout the 1980s and 1990s, reaching a low at the beginning of 2000s; Kilian and Vigfusson (2013) focus on the share of crude oil in U.S. GDP showing that the latter peaked in 1980/81, reached a trough in the late 1980s and began to rebound only after 2003, although it never reached the levels of 1980s. Consistently, Blanchard and Galì (2010) provide evidence that the share of oil in both U.S. production and consumption is smaller today than it was in the 1970s. The decline in the quantitative importance of oil appears to be present in a large number of countries. While Blanchard and Galì (2010) conjecture that this decline can account for a part of the decrease in the U.S. macroeconomic volatility conditional on oil shocks, Edelstein and Kilian (2009) show that fluctuations in the share of energy in consumption cannot explain the declining importance of energy price shocks.

In order to highlight the implications of lower oil shares, we simulate our model under different values of α_m. Figure 9, panel B illustrates that such a structural change reduces the negative impact of an oil supply disruption on exports. The reason is that it mitigates the recessionary effects of oil supply shocks on oil importing economies trading with each other.

By contrast, the reduction of oil shares in the world economy has a negligible impact on the response of exports to foreign productivity shocks (Figure 10; panel B). Indeed, in this case the bulk of the exports' movements in H depends on the cyclical expansion in F, which is almost unaffected by the change in the shares of oil.

5.3 Lower markups

There is widespread agreement that the global integration of the real and financial markets, the new ICT technologies and the process of European integration led to a strong and sharp increase in competitive pressures for the euro-area economies. The latter can be captured in our theoretical model by an increase in the elasticity of substitution among differentiated goods ϵ, that implies lower desired markups ($\frac{\epsilon}{\epsilon-1}$) in oil importing economies.

Figure 9 panel C shows that an increas in competitive pressure indeed reduces the impact of a negative oil supply shock on the exports of the oil importing countries. This happens because lower desired markups make the Phillips curves flatter, thus dampening the inflationary effect of oil price increases and consequently their recessionary effect. Milder recessions imply that the contraction of exports in these countries, which trade with each other, turns out to be smaller.

As displayed by Figure 10 panel C, the positive response of exports to faster foreign growth is amplified with lower desired markups, although the quantitative impact of this structural change is almost negligible.

6 Conclusions

This paper provides novel evidence on how the relationship between fluctuations of the real price of oil and exports in the euro area has changed over the last 40 years. The conjecture that motivates our analysis is that the milder recessionary impact of oil price shocks, amply documented in the literature, might partly stem from changes in the way euro-area foreign sales respond to the structural shocks that drive the real price of oil.

Our analysis is based on the interaction between a theoretical model and a structural VAR with time-varying coefficients and stochastic volatility. The theoretical model allows us to derive a set of restrictions on the signs of the impact response of the real price of oil, real exports, foreign (from the euro-area point of view) output and global oil production to two structural shocks: an unexpected fall in the supply of oil and a shock to foreign total factor productivity that also raises the demand for oil. By complementing these restrictions with plausible bounds on the price elasticity of oil supply and of oil demand, we identify these two shocks through our structural VAR, and study how their effect on euro area exports and on the co-movement between exports and the real price of oil has changed over time.

Our estimates indicate that the co-movement between euro-area exports and the real price of oil has become less negative conditional on oil supply shocks, and more positive conditional on oil demand shocks, pointing to the existence of some structural change influencing the joint dynamics of these two variables. Through the lens of our theoretical model, we qualitatively explore the role of a number of factors in accounting for such changes: larger export shares towards emerging countries, stronger competitive pressure in the product market and a reduction in the quantitative importance of oil in production. We show that a stronger trade relationship with emerging countries can potentially explain the increase in the positive correlation between euro area exports and the real price of oil conditional on foreign productivity shocks. However, such a structural change, taken in isolation, would lead to an even larger drop in exports following an oil supply shock, in contrast with our evidence. Instead, the more muted effect of an adverse oil supply shock can be accounted for by higher competitive pressure in the product market and by a decrease in the share of oil in production. We conclude that, in combination, these three factors could make a good job in explaining our evidence on the variations in the joint response of exports and energy prices to identified shocks.

Our analysis bears important policy implications, as it adds an international dimension to the assessment of the impact of oil price fluctuations on the macroeconomy, often confined to the domestic demand channel. For example, our results indicate that the stimulus for the euro-area economy stemming from the fall in the price of oil observed since the summer of 2014 is likely to be mild. On the one hand, insofar as this decrease reflects weakening global trade, it will be associated with lower foreign demand. Moreover, for a given shock to global output, the loss of foreign sales is likely to be more marked than in previous decades. On the other hand, to the extent that falling energy prices reflect also an increase in the supply of oil, the positive effect exerted on GDP through higher exports is likely to be negligible. Finally, our findings raise an interesting question on whether the fluctuations in the price of oil that we have observed since 2003 have played an important role in widening cross-country imbalances within the Monetary Union, an issue that we leave for future research.

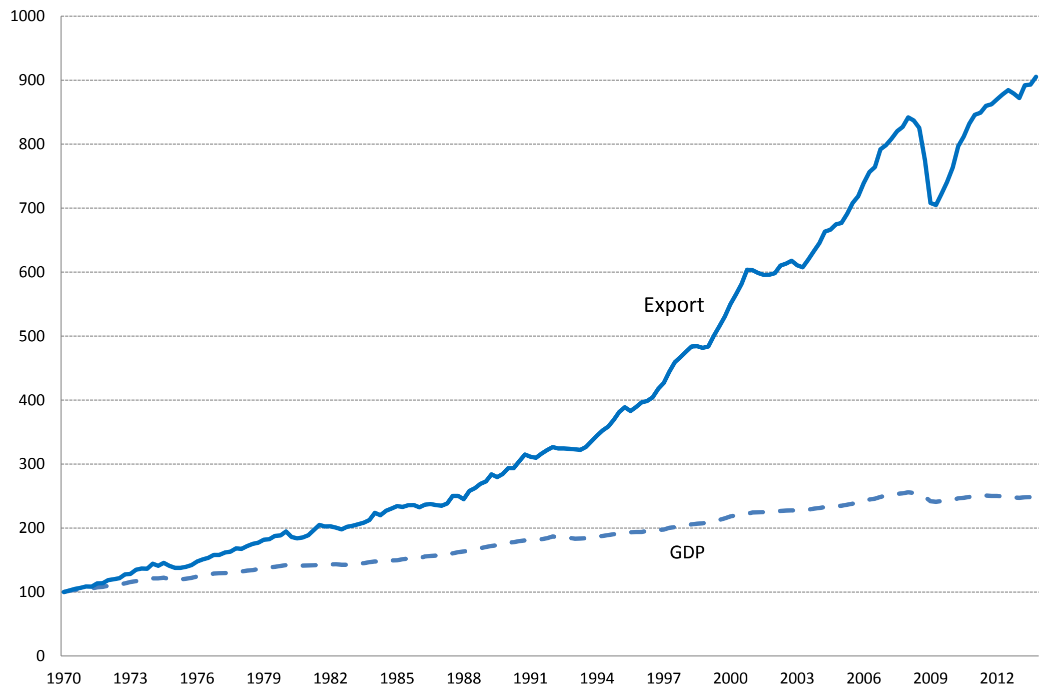


Figure 1: Real GDP and real exports in the euro area (1970q1=100)

	1970-1984	1985-2013
ρ	0.12	0.44
p-val	0.33	0.00

Table 1: Correlation between the growth rate of euro-area real exports and the growth rate of the real price of oil in the indicated sub-samples

	1	2	3	4
Regressors	Coefficient	p-val	Coefficient	p-val
intercept	5.49	0.00	5.23	0.00
Δ oil price	0.07	0.37	0.10	0.07
D1984	-0.78	0.52		
Δ oil price $\times$ D1984	0.16	0.07		
D1989			-0.67	0.56
Δ oil price $\times$ D1989			0.15	0.05

Table 2: Regression analysis. The dependent variable is the rate of growth of real exports, as defined in Section 2. The price of oil is the real price of crude oil, as defined in Section 2. D1984 is a dummy variable that equals 0 between the second quarter of 1970 and the fourth quarter of 1984, 1 otherwise. D1989 is a dummy variable that equals 0 between the second quarter of 1970 and the fourth quarter of 1989, 1 otherwise. The sample goes from the second quarter of 1970 to the fourth quarter of 2013 (175 observations).

	SIMULATED PARAMETERS	RANGE OF VALUES
θ	Price stickiness	$[0.1, 0.95]$
χ	Degree of trade openness in H	$[0.0, 1.0]$
χ^*	Degree of trade openness in F	$[0.0, 1.0]$
ϖ_O	Share of F-goods in the oil exporter country' consumers basket	$[0.0, 1.0]$
h	Habit	$[0.0, 0.999]$
ϕ_π	Taylor coefficient on inflation	$[1.1, 5.0]$
ϕ_x	Taylor coefficient on the output gap	$[0.0, 1.0]$
ϵ	Elasticity of substitution among differentiated goods	$[3, 11]$
ϕ	Inverse of the Frisch elasticity	$[0.1, 2.0]$
α_m	Oil's share in production	$[0.01, 0.04]$
ρ_m	Persistence of oil supply shock	$[0.5, 0.999]$
ρ_a	Persistence of foreign productivity shock	$[0.5, 0.999]$
	CALIBRATED PARAMETERS	
β	Intertemporal discount factor	0.998
σ	Risk aversion	0.1
α_n	Labor's share in production	2/3
n	Mass of households in H	0.5

Table 3: Ranges over which the indicated parameters are drawn in the Monte Carlo simulation of the theoretical model.

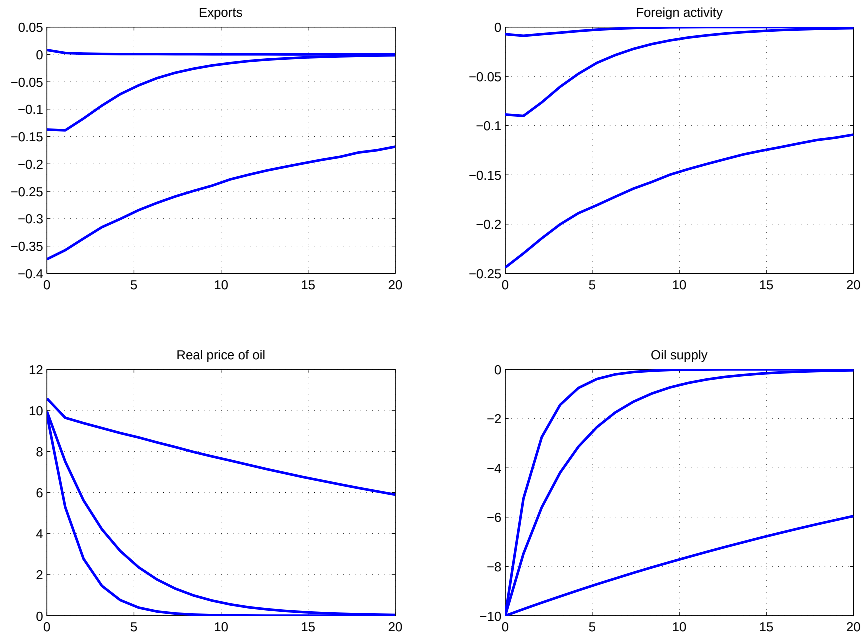


Figure 2: Theoretical IRFs to an oil supply shock. The Figure reports the median, the 5th, and 95th percentiles of the IRFs distribution.

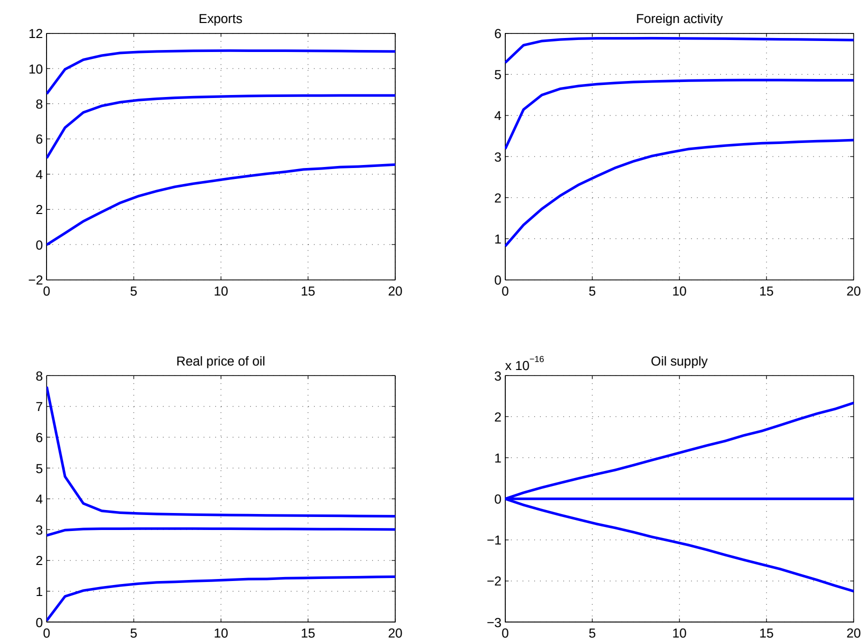


Figure 3: Theoretical IRFs to a foreign TFP shock. The Figure reports the median, the 5th, and 95th percentiles of the IRFs distribution.

	Structural shocks	
VAR variables	oil supply	foreign TFP
real price of oil	+	+
real export		+
foreign output	-	+
oil production	-	+

Table 4: Impact sign restrictions on the IRFs of the endogenous variables. A + (or−) indicates that the impulse response of the variable of interest is restricted to be positive (negative) on impact. A blank entry indicates that no restriction is imposed on the response.

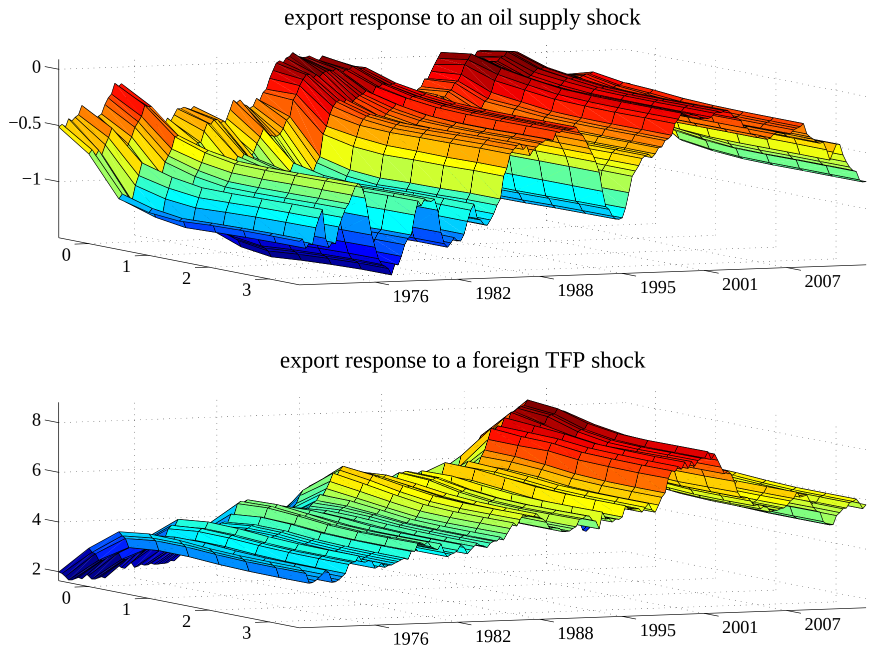


Figure 4: Cumulative Impulse Response Functions (IRFs) of export volumes. In each quarter the IRF is selected as the one that is closest to the mean IRF among those derived from the admissible structural models given the identifying restrictions. IRF to an oil supply shock are normalised to yield a 1% impact increase in oil prices. IRF to a foreign output shock are normalised to yield a 1% impact increase in foreign output.

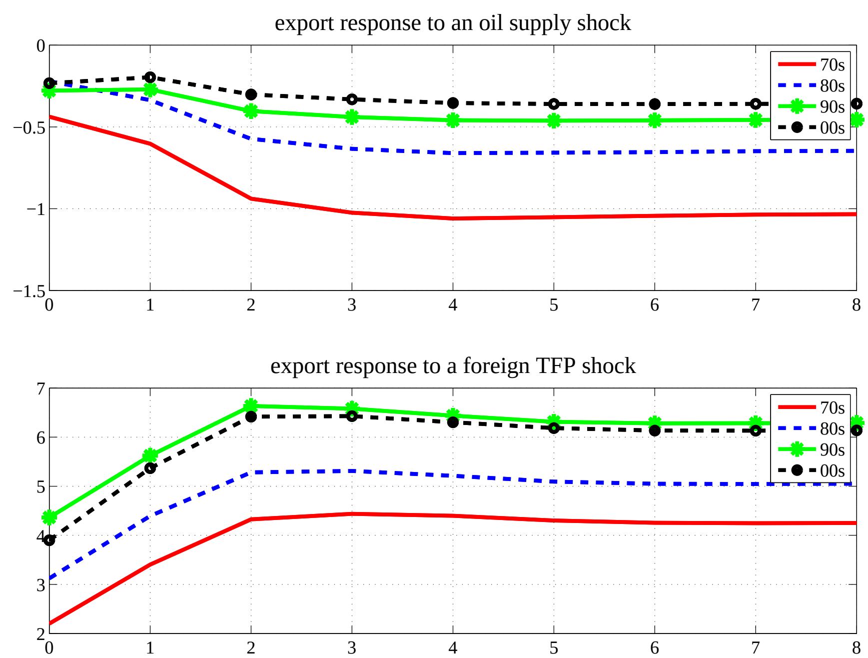


Figure 5: Cumulative Impulse Response Functions (IRFs) of export volumes in different decades. Each line shows the the time varying IRFs averaged over the quarters in the indicated decade. In each quarter the IRF is selected as the one that is closest to the mean IRF among those derived from the admissible structural models given the identifying restrictions. IRF to an oil supply shock are normalised to yield a 1% impact increase in oil prices. IRF to a foreign output shock are normalised to yield a 1% impact increase in foreign output.

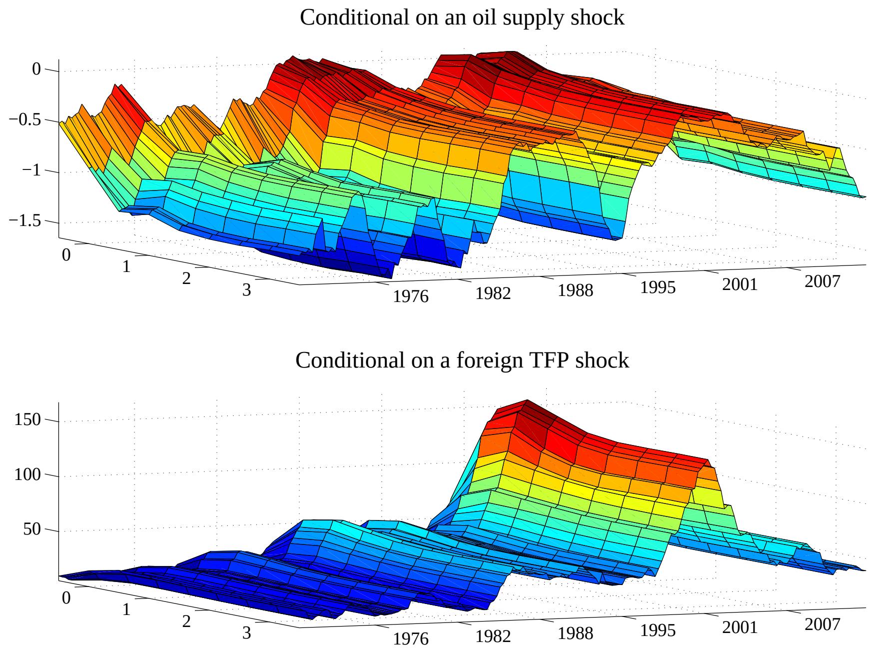


Figure 6: Covariances of the real price of oil and of export volumes conditional on structural shocks. Conditional covariances are obtained as the product of the cumulative IRFs of the price of oil and of exports to each structural shock, following den Haan and Sumner (2004).

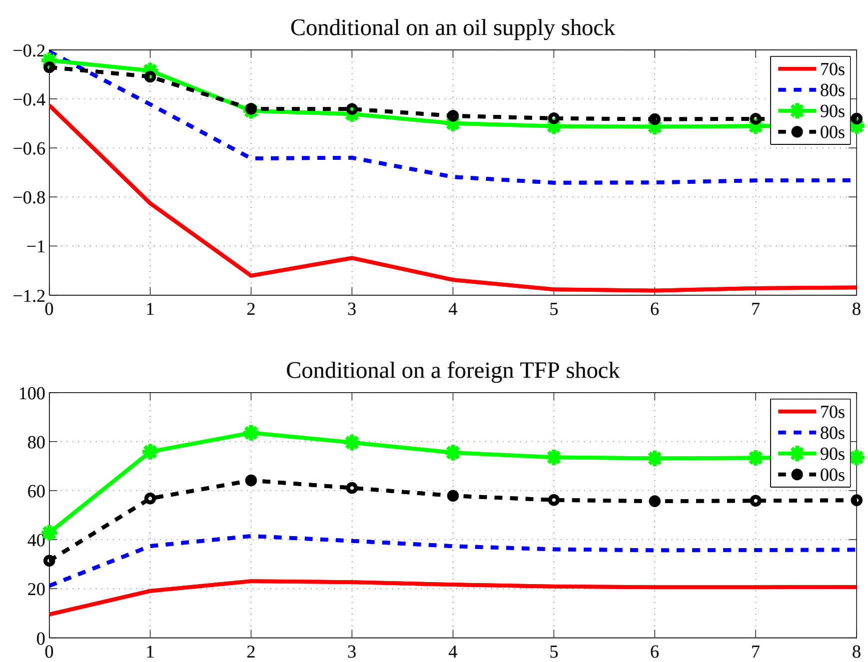


Figure 7: Covariances of the real price of oil and of export volumes conditional on structural shocks in different decades. Each line shows the the time varying conditional covariance averaged over the quarters in the indicated decade. Conditional covariances are obtained as the product of the cumulative IRFs of the price of oil and of exports to each structural shock, following den Haan and Sumner (2004).

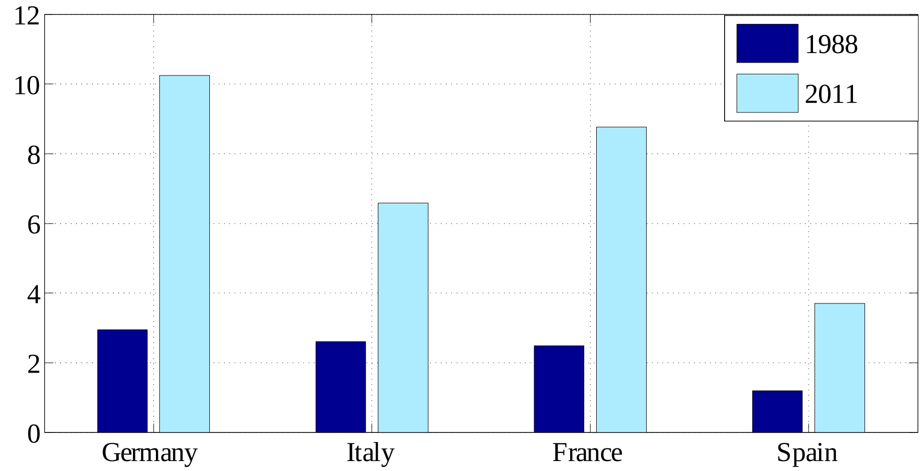
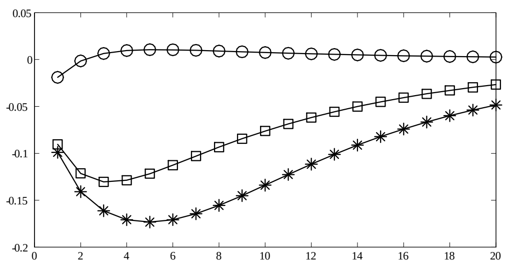


Figure 8. Export shares towards Asian Emerging Countries. The share of exports is computed as the ratio of exports (in current values) by destination country over total exports. Asian Emerging Countries are China, South Korea,Hong Kong, Malaysia, Singapore, Taiwan, Thailand.

a. Stronger trade relationship with emerging economies

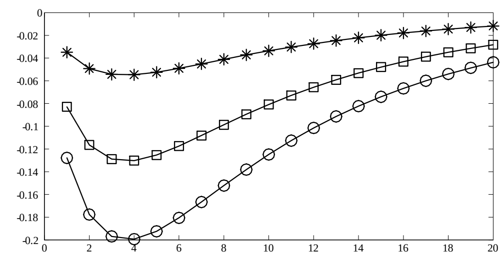


− ◯ − $\chi^*= 0.05$

− ⊡ − $\chi^*= 0.30$

− ∗ − $\chi^*= 1.00$

b. Lower oil shares

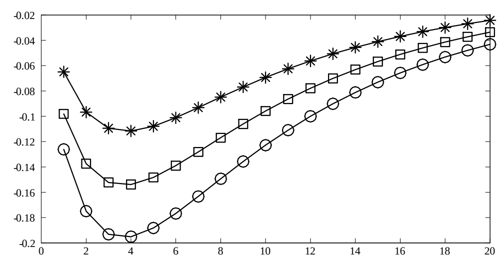


− ◯ − $\alpha_m= 0.040$

− ⊡ − $\alpha_m= 0.025$

− ∗ − $\alpha_m= 0.010$

c. Lower markups



− ◯ − $\epsilon= 3.0$ (desired markup 50%)

− ⊡ − $\epsilon= 6.0$ (desired markup 20%)

− ∗ − $\epsilon= 11.0$ (desired markup 10 %)

Figure 9. Theoretical IRFs of exports from H to an oil supply shock. IRFs are obtained by simulating the theoretical model under a 10 per cent reduction in oil supply for different calibrated values of χ^*(panel a), α_m (panel b) and ϵ (panel c). The remaining parameters are calibrated consistently with the Monte Carlo simulation performed in Section 3.7.

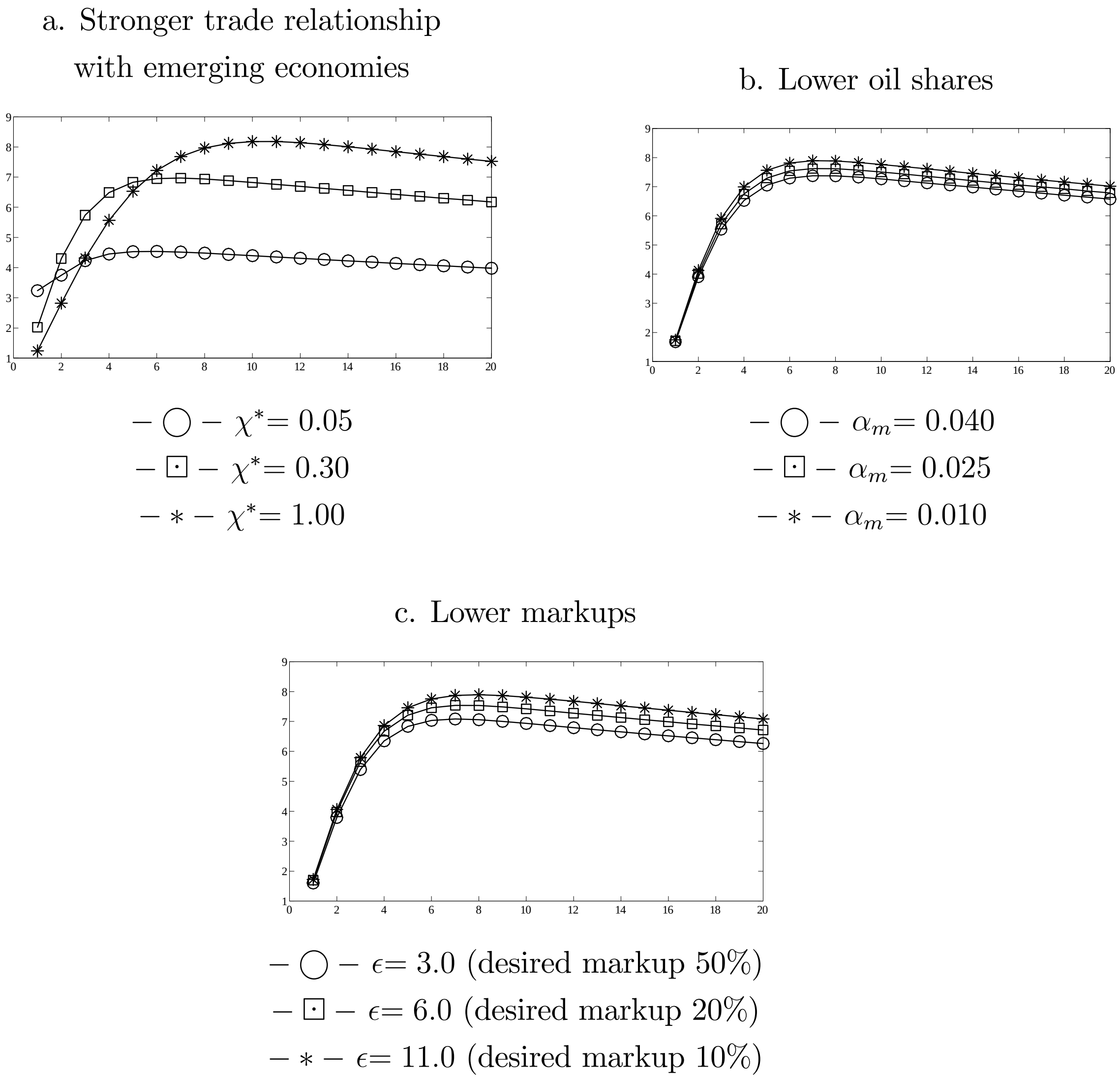


Figure 10. Theoretical IRFs of exports from H to an oil demand shock. IRFs are obtained by simulating the theoretical model under foreign productivity shock, normalized to increase foreign GDP by 1 percent, for different calibrated values of χ^*(panel a), α_m (panel b) and ϵ (panel c). The remaining parameters are calibrated consistently with the Monte Carlo simulation performed in Section 3.7.

Appendix A

First order conditions

The optimality conditions implied by the maximization of (1) subject to the budget constraint are the stochastic Euler equation:

$$1 = \frac{\beta}{Q_t^B}\mathbb{E}_t\left\{\frac{P_t}{P_{t+1}}\frac{(C_t - hC_{t-1})^{\sigma}}{(C_{t+1} - hC_t)^{\sigma}}\right\} \tag{13}$$

and the intratemporal optimality condition:

$$\frac{W_{H,t}}{P_t} = N_t^{\phi}\left(C_t - hC_{t-1}\right) \tag{14}$$

The optimal price-setting strategy for the typical firm resetting its price in period t is:

$$E_t\left\{\sum_{k=0}^{\infty}\theta^k Q_{t,t+k}Y_{t+k/t}\left(\widetilde{P}_{H,t} - \frac{\epsilon}{\epsilon-1}\Psi_{t+k/t}\right)\right\} = 0 \tag{15}$$

where $Q_{t,t+k}$ is the stochastic discount factor for nominal payoffs, $\widetilde{P}_{H,t}$ denotes the price newly set at time t, $Y_{t+k/t}$ and $\Psi_{t+k/t}$ are the level of output and the (nominal) marginal cost in period in period $t+k$ for a firm that last set its price in period t and $\frac{\epsilon}{\epsilon-1}$ measures the desired markup.

In the oil producing country, the optimal allocation of expenditures between F and H-produced goods implies:

$$C_{H,t}^O = (1 - \varpi_O)\, C_t^O \frac{P_t^O}{P_{H,t}} \tag{16}$$

$$C_{F,t}^O = \varpi_O C_t^O \frac{P_t^O}{P_{F,t}} \tag{17}$$

where P_t^O denotes the aggregate price level in the oil-producing economy $P_t^O = P_{H,t}^{1-\varpi_O} P_{F,t}^{\varpi_O}$.

Steady state relations

From cost minimization we can write:

$$\frac{M^H}{M^F} = \frac{NW_H}{N^* W_F} \tag{18}$$

Equation (14) implies that $W_H = N^{\phi}\left[C - hC\right]P$ and $W_F = N^{*\phi}\left[C^* - hC^*\right]P^*\mathcal{E}$. Note that

$$P^*\mathcal{E} = \left(P_H^*\mathcal{E}\right)^{\gamma^*} \left(P_F^*\mathcal{E}\right)^{(1-\gamma^*)} = \left(P_H\right)^{\gamma^*} \left(P_F\right)^{(1-\gamma^*)} \tag{19}$$

Accordingly we can write:

$$\frac{W_H}{W_F} = \frac{N^\phi}{N^{*\phi}} \frac{C}{C^*} \frac{P_H^{1-\gamma-\gamma^*}}{P_F^{1-\gamma^*-\gamma}} = \frac{N^\phi}{N^{*\phi}} \frac{C}{C^*} S^{-(1-\gamma^*-\gamma)} \tag{20}$$

where $S \equiv \frac{P_F}{P_H}$ is the *terms of trade* between the domestic economy and F, i.e. the relative price of foreign goods. Combining (18) and (20) we get:

$$\frac{M^H}{M^F} = \frac{N^{1+\phi}}{N^{*1+\phi}} \frac{C}{C^*} S^{-(1-\gamma^*-\gamma)} \tag{21}$$

We define $\Gamma \equiv \frac{C}{Y}$ and $\Gamma^* \equiv \frac{C^*}{Y^*}$. Accordingly

$$\frac{C}{C^*} = \frac{\Gamma Y}{\Gamma^* Y^*} = \frac{\Gamma N^{\alpha_n} M_H^{\alpha_m}}{\Gamma^* N^{*\alpha_n} M_F^{\alpha_m}} \tag{22}$$

Taken into account that $M_{Ht} = \frac{\alpha_m}{\mathcal{M}_t^p} \frac{Y_t}{P_{m,t}} P_{H,t}$ and $M^F = \frac{\alpha_m}{\mathcal{M}_t^{*p}} \frac{Y_t^*}{P_{m,t}} P_{F,t}$, we get:

$$\frac{Y}{Y^* S} = \frac{M^H}{M^F} \tag{23}$$

Combining (23) with (21) and (22) yields:

$$\frac{N^{1+\phi}}{N^{*1+\phi}} \frac{\Gamma}{\Gamma^*} S^{(\gamma^*+\gamma)} = 1 \tag{24}$$

We conclude that the steady state terms of trade can be written as:

$$S = \left[\frac{\Gamma^*}{\Gamma} \left(\frac{N^*}{N}\right)^{1+\phi}\right]^{\frac{1}{\gamma^*+\gamma}} \tag{25}$$

Combining (21) with (22) we can write:

$$\left(\frac{M^H}{M^F}\right)^{1-\alpha_m} = \left(\frac{N}{N^*}\right)^{1+\phi+\alpha_n} S^{-(1-\gamma^*-\gamma)} \frac{\Gamma}{\Gamma^*}$$

which implies, using (25):

$$\frac{M^H}{M^F} = \left(\frac{N}{N^*}\right)^{\frac{1+\phi+\alpha_n}{(1-\alpha_m)} + (1+\phi)\frac{(1-\gamma^*-\gamma)}{(\gamma^*+\gamma)(1-\alpha_m)}} \left(\frac{\Gamma}{\Gamma^*}\right)^{\frac{1}{(\gamma^*+\gamma)(1-\alpha_m)}} \tag{26}$$

To recover $\frac{C_H}{Y}$ and $\frac{C_F^*}{Y^*}$, we consider $P_{H,t}C_{H,t} = (1-\gamma) P_t C_t$ and $P_{F,t}^* C_{F,t}^* = (1-\gamma^*) P_t^* C_t^*$

in steady state and get:

$$\frac{C_H}{Y} = \Gamma\left(1-\gamma\right)S^{\gamma} \tag{27}$$

$$\frac{C^*_{F,t}}{Y^*} = \Gamma^*\left(1-\gamma^*\right)S^{-\gamma^*} \tag{28}$$

Note also that considering $P^*_{H,t}C^*_{H,t} = \gamma^* P^*_t C^*_t$ in steady state together with (23), one obtains:

$$\frac{C^*_H}{Y} = \frac{M^F}{M^H}\gamma^* S^{(-\gamma^*)}\Gamma^*$$

and similarly

$$\frac{C_F}{Y^*} = \frac{M^H}{M^F}\gamma\Gamma S^{\gamma} \tag{29}$$

Finally, in order to recover $\frac{C^O_H}{Y}$, let consider (16) together with the consumer's budget constraint:

$$\frac{C^O_H}{Y} = \left(1-\varpi_O\right)\frac{P_m M^s}{Y P_H}$$

Taking into account (7) we can write:

$$\frac{C^O_H}{Y} = \left(1-\varpi_O\right)\left(\frac{nM^H P_m}{Y P_H} + \frac{\left(1-n\right)M^F P_m}{Y P_H}\right) \tag{30}$$

By combining (30) with $M^H = \alpha_m \frac{P_H}{P_m}\frac{\epsilon-1}{\epsilon}Y$ we get:

$$\frac{C^O_H}{Y} = \left(1-\varpi_O\right)\left[n\frac{\epsilon-1}{\epsilon}\alpha_m + \left(1-n\right)S\frac{Y^*}{Y}\frac{\epsilon-1}{\epsilon}\alpha_m\right] \tag{31}$$

that can be combined with (23) to get:

$$\frac{C^O_H}{Y} = \left(1-\varpi_O\right)\frac{\epsilon-1}{\epsilon}\alpha_m\left[n + \left(1-n\right)\frac{M^F}{M^H}\right] \tag{32}$$

Similarly, in order to recover $\frac{C^O_F}{Y^*}$, let consider (17) together with the consumer's budget constraint:

$$\frac{C^O_F}{Y^*} = \varpi_O\frac{P_m M^s}{Y^* P_F} \tag{33}$$

Taking into account (7) and $M^H = \alpha_m \frac{P_H}{P_m}\frac{\epsilon-1}{\epsilon}Y$ we can write:

$$\frac{C_F^O}{Y^*} = \varpi_O \left(n \frac{Y}{Y^* S} \frac{\epsilon - 1}{\epsilon} \alpha_m + (1-n) \frac{\epsilon - 1}{\epsilon} \alpha_m \right) \tag{34}$$

Finally, considering (23) one obtains:

$$\frac{C_F^O}{Y^*} = \varpi_O \left(n \frac{M^H}{M^F} \frac{\epsilon - 1}{\epsilon} \alpha_m + (1-n) \frac{\epsilon - 1}{\epsilon} \alpha_m \right) \tag{35}$$

Appendix B

Data and prior distributions

- Oil supply for the years 1973-2013 is world crude oil production (thousand barrels per day) reported in the April 2015 Monthly Energy Review by the U.S. Energy Information Administration. For the years 1970-1972 we use annual data from the December 2010 International Petroleum Monthly (also published by the Energy Information Administration) and convert it to the quarterly frequency using a quadratic spline.

- Euro area exports are chain linked volumes from the ECB Area Wide Model (AWM) database.

- The real price of oil is obtained by first converting in euros the price of crude Brent, then deflating the resulting nominal price (denominated in euros) by the euro area GDP deflator. The nominal price of oil in U.S. dollar (Brent quality), the euro/U.S. dollar exchange rate and the GDP deflator are all obtained from the ECB-AWM database.

- Foreign GDP is constructed following the methodology described in the Appendix in Hahn and Mestre (2011). Annual and quarterly GDP data are taken from the Economic Outlook, OECD database (GDP volumes at the price levels and PPP of 2000). Starting from the sum of annual GDP, the quarterly series is obtained by interpolating with the Chow Lin methodology. Data are available for the following countries: Australia, Austria, Brazil, Canada, China, Czech Republic, Chile, Denmark, Estonia, Finland, UK, Hungary, India, Iceland, Japan, Korea, Mexico, Norway, New Zealand, Poland, the Slovak Republic, Sweden, Turkey, and the United States.

The prior distributions for the initial values of the states (θ_0, a_0 and λ_0) of the VAR are postulated to be all normal, and independent both from one another, and from the distribution of the hyperparameters. The calibration of the mean and of the variance of the prior distribution of θ_0 follows the standard approach of using the output of the estimate of a time-invariant VAR over a training period. Since our data sample is relatively short, rather than discarding data we use the period 1970-1985, a strategy suggested for example, by Canova and Ciccarelli (2009). The rest of the procedure to set up the priors follows step by step Benati and Mumtaz (2007), pages 9 to 11. The simulation algorithm used to obtain the posterior distribution of the parameters is also taken from Benati and Mumtaz (2007), pages 11 and 12. In the Monte Carlo Markov Chain procedure we use 10.000 replications and discard the first 5.000.

References

[1] Aastveit, K. A., Bjornland, H. C. and Thorsrud, L. A. (2013), What Drives Oil Prices? Emerging versus Developed Economies, Working papers Norges Bank, 2012, 11.

[2] Baumeister, C. and Peersman, G. (2013a), The Role Of Time-Varying Price Elasticities In Accounting For Volatility Changes In The Crude Oil Market, *Journal of Applied Econometrics*, 28(7), 1087-1109.

[3] Baumeister, C. and Peersman, G. (2013b), Time-Varying Effects of Oil Supply Shocks on the U.S. Economy, *American Economic Journal: Macroeconomics*, 5(4), 1-28.

[4] Benati, L. (2007), Drift And Breaks In Labor Productivity, *Journal of Economic Dynamics and Control*, 31(8), 2847-2877.

[5] Benati, L. and Mumtaz, H. (2007), U.S. Evolving Macroeconomic Dynamics: A Structural Investigation, Working Paper Series 746, European Central Bank.

[6] Blanchard, O. J. and Galì, J. (2010), The Macroeconomic Effects of Oil Shocks: Why are the 2000s So Different from the 1970s?, NBER Chapters, in: International Dimensions of Monetary Policy, 373-421, National Bureau of Economic Research Inc.

[7] Blanchard, O.J. and Riggi, M. (2013), Why Are the 2000s So Different from the 1970s? A Structural Interpretation of Changes in the Macroeconomic Effects of Oil Prices in the U.S., *Journal of the European Economic Association*, 11(5), 1032-1052.

[8] Calvo, G. A. (1983), Staggered Prices in a Utility-Maximizing Framework, *Journal of Monetary Economics*, 12(3), 383-398.

[9] Campolmi, A. (2008), Oil Price Shocks: Demand vs Supply in a Two-Country Model, Magyar Nemzeti Bank Working Paper, 2008/5.

[10] Canova, F. and Ciccarelli, M. (2009), Estimating Multicountry Var Models, *International Economic Review*, 50, 929–959.

[11] Canova, F. and Paustian, M. (2011), Business Cycle Measurement With Some Theory, *Journal of Monetary Economics*, 58(4), 345-361.

[12] Clarida, R., Galì, J. and Gertler, M. (2002), A Simple Framework for International Monetary Policy Analysis, *Journal of Monetary Economics*, 49, 879-904.

[13] Dedola, L. and Neri, S. (2007), What Does A Technology Shock Do? A VAR Analysis with Model-Based Sign Restrictions, *Journal of Monetary Economics*, 54, 512-549.

[14] den Haan, W. J., and Sumner, S.V. (2004), The Comovement between Real Activity and Prices in the G7, *European Economic Review*, 48, 1333–1347.

[15] Edelstein, P. and Kilian, L. (2009), How Sensitive Are Consumer Expenditures to Retail Energy Prices?, *Journal of Monetary Economics*, 56, 766-779.

[16] Fry, R. and Pagan, A. (2011), Sign Restrictions in Structural Vector Autoregressions: A Critical Review, *Journal of Economic Literature*, 49(4), 938-60.

[17] Hamilton, J.D. (2009), Understanding Crude Oil Prices, *Energy Journal*, 30(2), 179-206.

[18] Hahn, E. and Mestre, R. (2011), The Role of Oil Prices in the Euro Area Economy Since the 1970s, Working Paper Series 1356, European Central Bank.

[19] Higgins M., Klitgaard, T. and Lerman, R. (2006), Recycling Petrodollars, *Current Issues in Economics and Finance*, 12(9), Federal Reserve Bank of New York.

[20] Hooker, M.A. (1999), Oil and the Macroeconomy Revisited, Finance and Economics Discussion Series 1999-43, Board of Governors of the Federal Reserve System (U.S.).

[21] Inoue, A and Kilian, L. (2013), Inference on Impulse Response Functions in Structural VAR Models, *Journal of Econometrics*, 177(1), 1-13.

[22] Kilian, L. (2008), A Comparison Of The Effects Of Exogenous Oil Supply Shocks On Output And Inflation In The G7 Countries, *Journal of the European Economic Association*, 6, 78–121.

[23] Kilian, L. (2009), Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market, *American Economic Review*, 99(3), 1053-69.

[24] Kilian, L., and Hicks, B. (2013), Did Unexpectedly Strong Economic Growth Cause the Oil Price Shock of 2003-2008?, *Journal of Forecasting*, 32(5), 385–394.

[25] Kilian, L. and Murphy, D. P. (2012), Why Agnostic Sign Restrictions Are Not Enough: Understanding The Dynamics Of Oil Market VAR Models, *Journal of the European Economic Association*, 10, 1166–1188.

[26] Kilian, L. and Murphy, D. P. (2014), The Role Of Inventories And Speculative Trading In The Global Market For Crude Oil, *Journal of Applied Econometrics*, 29, 454–478.

[27] Kilian, L., Rebucci, A. and Spatafora, N. (2009), Oil shocks and external balances, *Journal of International Economics*, 77(2), 181-194.

[28] Kilian, L. and Vigfusson, C. (2013), Do Oil Prices Help Forecast US Real GDP? The Role of Nonlinearities and Asymmetries, *Journal of Business and Economic Statistics*, 31(1), 78-93.

[29] Lipinska, A and Millard, S. (2012), Tailwinds and Headwinds: How Does Growth in the BRICs Affect Inflation in the G-7?, *International Journal of Central Banking,* 8(1), 227-266.

[30] Lippi, F. and Nobili, A. (2012), Oil And The Macroeconomy: A Quantitative Structural Analysis, *Journal of the European Economic Association*, 10(5), 1059-1083.

[31] Rubio-Ramirez, J. F., Waggoner, D. F. and Zha, T. (2010), Structural Vector Autoregressions: Theory of Identification and Algorithms for Inference, *Review of Economic Studies*, 77(2), 665-696.

[32] Unalmis D., Unalmis, I. and Unsal, D. F. (2012), On Oil Price Shocks: The Role of Storage, IMF Economic Review, 60(4), 505-532.

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A. ANZUINI, M. J. LOMBARDI and P. PAGANO, *The impact of monetary policy shocks on commodity prices*, International Journal of Central Banking, v. 9, 3, pp. 119-144, **TD No. 851 (February 2012).**

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G. ASCARI and T. ROPELE, *Disinflation effects in a medium-scale new keynesian model: money supply rule versus interest rate rule,* European Economic Review, v. 61, pp. 77-100, **TD No. 867 (April 2012).**

E. BERETTA and S. DEL PRETE, *Banking consolidation and bank-firm credit relationships: the role of geographical features and relationship characteristics,* Review of Economics and Institutions, v. 4, 3, pp. 1-46, **TD No. 901 (February 2013).**

M. ANDINI, G. DE BLASIO, G. DURANTON and W. STRANGE, *Marshallian labor market pooling: evidence from Italy,* Regional Science and Urban Economics, v. 43, 6, pp.1008-1022, **TD No. 922 (July 2013).**

G. SBRANA and A. SILVESTRINI, *Forecasting aggregate demand: analytical comparison of top-down and bottom-up approaches in a multivariate exponential smoothing framework,* International Journal of Production Economics, v. 146, 1, pp. 185-98, **TD No. 929 (September 2013).**

A. FILIPPIN, C. V, FIORIO and E. VIVIANO, *The effect of tax enforcement on tax morale,* European Journal of Political Economy, v. 32, pp. 320-331, **TD No. 937 (October 2013).**

2014

G. M. TOMAT, *Revisiting poverty and welfare dominance*, Economia pubblica, v. 44, 2, 125-149, **TD No. 651 (December 2007).**

M. TABOGA, *The riskiness of corporate bonds*, Journal of Money, Credit and Banking, v.46, 4, pp. 693-713, **TD No. 730 (October 2009).**

G. MICUCCI and P. ROSSI, *Il ruolo delle tecnologie di prestito nella ristrutturazione dei debiti delle imprese in crisi*, in A. Zazzaro (a cura di), Le banche e il credito alle imprese durante la crisi, Bologna, Il Mulino, **TD No. 763 (June 2010).**

F. D'AMURI, *Gli effetti della legge 133/2008 sulle assenze per malattia nel settore pubblico,* Rivista di politica economica, v. 105, 1, pp. 301-321, **TD No. 787 (January 2011).**

R. BRONZINI and E. IACHINI, *Are incentives for R&D effective? Evidence from a regression discontinuity approach,* American Economic Journal : Economic Policy, v. 6, 4, pp. 100-134, **TD No. 791 (February 2011).**

P. ANGELINI, S. NERI and F. PANETTA, *The interaction between capital requirements and monetary policy*, Journal of Money, Credit and Banking, v. 46, 6, pp. 1073-1112, **TD No. 801 (March 2011).**

M. BRAGA, M. PACCAGNELLA and M. PELLIZZARI, *Evaluating students' evaluations of professors,* Economics of Education Review, v. 41, pp. 71-88, **TD No. 825 (October 2011).**

M. FRANCESE and R. MARZIA, *Is there Room for containing healthcare costs? An analysis of regional spending differentials in Italy,* The European Journal of Health Economics, v. 15, 2, pp. 117-132, **TD No. 828 (October 2011).**

L. GAMBACORTA and P. E. MISTRULLI, *Bank heterogeneity and interest rate setting: what lessons have we learned since Lehman Brothers?,* Journal of Money, Credit and Banking, v. 46, 4, pp. 753-778, **TD No. 829 (October 2011).**

M. PERICOLI, *Real term structure and inflation compensation in the euro area*, International Journal of Central Banking, v. 10, 1, pp. 1-42, **TD No. 841 (January 2012).**

E. GENNARI and G. MESSINA, *How sticky are local expenditures in Italy? Assessing the relevance of the flypaper effect through municipal data,* International Tax and Public Finance, v. 21, 2, pp. 324-344, **TD No. 844 (January 2012).**

V. DI GACINTO, M. GOMELLINI, G. MICUCCI and M. PAGNINI, *Mapping local productivity advantages in Italy: industrial districts, cities or both?*, Journal of Economic Geography, v. 14, pp. 365–394, **TD No. 850 (January 2012).**

A. ACCETTURO, F. MANARESI, S. MOCETTI and E. OLIVIERI, *Don't Stand so close to me: the urban impact of immigration,* Regional Science and Urban Economics, v. 45, pp. 45-56, **TD No. 866 (April 2012).**

M. PORQUEDDU and F. VENDITTI, *Do food commodity prices have asymmetric effects on euro area inflation,* Studies in Nonlinear Dynamics and Econometrics, v. 18, 4, pp. 419-443, **TD No. 878 (September 2012).**

S. FEDERICO, *Industry dynamics and competition from low-wage countries: evidence on Italy*, Oxford Bulletin of Economics and Statistics, v. 76, 3, pp. 389-410, **TD No. 879 (September 2012).**

F. D'AMURI and G. PERI, *Immigration, jobs and employment protection: evidence from Europe before and during the Great Recession,* Journal of the European Economic Association, v. 12, 2, pp. 432-464, **TD No. 886 (October 2012).**

M. TABOGA, *What is a prime bank? A euribor-OIS spread perspective,* International Finance, v. 17, 1, pp. 51-75, **TD No. 895 (January 2013).**

G. CANNONE and D. FANTINO, *Evaluating the efficacy of european regional funds for R&D,* Rassegna italiana di valutazione, v. 58, pp. 165-196, **TD No. 902 (February 2013).**

L. GAMBACORTA and F. M. SIGNORETTI, *Should monetary policy lean against the wind? An analysis based on a DSGE model with banking,* Journal of Economic Dynamics and Control, v. 43, pp. 146-74, **TD No. 921 (July 2013).**

M. BARIGOZZI, CONTI A.M. and M. LUCIANI, *Do euro area countries respond asymmetrically to the common monetary policy?,* Oxford Bulletin of Economics and Statistics, v. 76, 5, pp. 693-714, **TD No. 923 (July 2013).**

U. ALBERTAZZI and M. BOTTERO, *Foreign bank lending: evidence from the global financial crisis,* Journal of International Economics, v. 92, 1, pp. 22-35, **TD No. 926 (July 2013).**

R. DE BONIS and A. SILVESTRINI, *The Italian financial cycle: 1861-2011,* Cliometrica, v.8, 3, pp. 301-334, **TD No. 936 (October 2013).**

G. BARONE and S. MOCETTI, *Natural disasters, growth and institutions: a tale of two earthquakes,* Journal of Urban Economics, v. 84, pp. 52-66, **TD No. 949 (January 2014).**

D. PIANESELLI and A. ZAGHINI, *The cost of firms' debt financing and the global financial crisis,* Finance Research Letters, v. 11, 2, pp. 74-83, **TD No. 950 (February 2014).**

A. ZAGHINI, *Bank bonds: size, systemic relevance and the sovereign,* International Finance, v. 17, 2, pp. 161-183, **TD No. 966 (July 2014).**

G. SBRANA and A. SILVESTRINI, *Random switching exponential smoothing and inventory forecasting,* International Journal of Production Economics, v. 156, 1, pp. 283-294, **TD No. 971 (October 2014).**

M. SILVIA, *Does issuing equity help R&D activity? Evidence from unlisted Italian high-tech manufacturing firms,* Economics of Innovation and New Technology, v. 23, 8, pp. 825-854, **TD No. 978 (October 2014).**

2015

M. BUGAMELLI, S. FABIANI and E. SETTE, *The age of the dragon: the effect of imports from China on firm-level prices*, Journal of Money, Credit and Banking, v. 47, 6, pp. 1091-1118, **TD No. 737 (January 2010).**

G. BULLIGAN, M. MARCELLINO and F. VENDITTI, *Forecasting economic activity with targeted predictors,* International Journal of Forecasting, v. 31, 1, pp. 188-206, **TD No. 847 (February 2012).**

A. CIARLONE, *House price cycles in emerging economies,* Studies in Economics and Finance, v. 32, 1, **TD No. 863 (May 2012).**

D. FANTINO, A. MORI and D. SCALISE, *Collaboration between firms and universities in Italy: the role of a firm's proximity to top-rated departments,* Rivista Italiana degli economisti, v. 1, 2, pp. 219-251, **TD No. 884 (October 2012).**

G. BARONE and G. NARCISO, *Organized crime and business subsidies: Where does the money go?,* Journal of Urban Economics, v. 86, pp. 98-110, **TD No. 916 (June 2013).**

P. ALESSANDRI and B. NELSON, *Simple banking: profitability and the yield curve,* Journal of Money, Credit and Banking, v. 47, 1, pp. 143-175, **TD No. 945 (January 2014).**

R. AABERGE and A. BRANDOLINI, *Multidimensional poverty and inequality,* in A. B. Atkinson and F. Bourguignon (eds.), Handbook of Income Distribution, Volume 2A, Amsterdam, Elsevier, **TD No. 976 (October 2014).**

V. CUCINIELLO and F. M. SIGNORETTI, *Large banks,loan rate markup and monetary policy,* International Journal of Central Banking, v. 11, 3, pp. 141-177, **TD No. 987 (November 2014).**

M. FRATZSCHER, D. RIMEC, L. SARNOB and G. ZINNA, *The scapegoat theory of exchange rates: the first tests,* Journal of Monetary Economics, v. 70, 1, pp. 1-21, **TD No. 991 (November 2014).**

A. NOTARPIETRO and S. SIVIERO, *Optimal monetary policy rules and house prices: the role of financial frictions,* Journal of Money, Credit and Banking, v. 47, S1, pp. 383-410, **TD No. 993 (November 2014).**

R. ANTONIETTI, R. BRONZINI and G. CAINELLI, *Inward greenfield FDI and innovation,* Economia e Politica Industriale, v. 42, 1, pp. 93-116, **TD No. 1006 (March 2015).**

FORTHCOMING

G. DE BLASIO, D. FANTINO and G. PELLEGRINI, *Evaluating the impact of innovation incentives: evidence from an unexpected shortage of funds,* Industrial and Corporate Change, **TD No. 792 (February 2011).**

A. DI CESARE, A. P. STORK and C. DE VRIES, *Risk measures for autocorrelated hedge fund returns,* Journal of Financial Econometrics, **TD No. 831 (October 2011).**

E. BONACCORSI DI PATTI and E. SETTE, *Did the securitization market freeze affect bank lending during the financial crisis? Evidence from a credit register,* Journal of Financial Intermediation, **TD No. 848 (February 2012).**

M. MARCELLINO, M. PORQUEDDU and F. VENDITTI, *Short-Term GDP Forecasting with a mixed frequency dynamic factor model with stochastic volatility,* Journal of Business & Economic Statistics, **TD No. 896 (January 2013).**

M. ANDINI and G. DE BLASIO, *Local development that money cannot buy: Italy's Contratti di Programma,* Journal of Economic Geography, **TD No. 915 (June 2013).**

J. LI and G. ZINNA, *On bank credit risk: sytemic or bank-specific? Evidence from the US and UK,* Journal of Financial and Quantitative Analysis, **TD No. 951 (February 2015).**

A. L. MANCINI, C. MONFARDINI and S. PASQUA, *Is a good example the best sermon? Children's imitation of parental reading,* Review of Economics of the Household, **TD No. 958 (April 2014).**

L. BURLON, *Public expenditure distribution, voting, and growth,* Journal of Public Economic Theory, **TD No. 961 (April 2014).**

A. BRANDOLINI and E. VIVIANO, *Behind and beyond the (headcount) employment rate,* Journal of the Royal Statistical Society: Series A, **TD No. 965 (July 2015).**