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ENERGY PRICES IN THE BANK OF ITALY MACROECONOMETRIC MODEL

by Pietro Cova*, Davide Fantino* and Lisa Rodano*

Abstract

The sharp increases in energy commodity prices, and in particular in natural gas prices, in 2021 and 2022 led to a notable surge in inflation in Italy and the euro area. We extend the Bank of Italy's quarterly econometric model (BIQM) to adequately capture the direct and indirect inflationary and macroeconomic effects of the extraordinary increases in energy prices, modelling gas and oil prices separately. We assess the forecasting properties of the model and also evaluate the impact of the measures taken by governments to counter the macroeconomic consequences of the energy crisis.

JEL Classification: C30, E10, E17.

Keywords: macro-econometric models, Italy, forecasting, policy simulation.

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* Banca d'Italia, Directorate General for Economics, Statistics and Research.

E-mail: pietro.cova@bancaditalia.it, davide.fantino@bancaditalia.it, marialisa.rodano@bancaditalia.it.

1. Introduction: Tracking gas prices in the BIQM[1]

The aim of the present paper is to document how the Bank of Italy quarterly econometric model (BIQM) has been extended to incorporate the international price of natural gas among the prices of imported energy. Furthermore, the structure of the model that refers to the final energy consumption prices and quantities has been enriched to include gas, separately from those of the other energy sources. Finally, building upon this expanded structure of the energy block, estimates of GDP growth and inflation rates of the Government measures introduced to counter the macroeconomic consequences of the spikes in the energy prices observed between 2021-2023 are presented and compared with those obtained from the version of BIQM that does not include a separate role for gas.[2]

The European energy crisis, which originated in 2021 and that abruptly escalated following the outbreak of the war in Ukraine, has had a structural effect on the level and dynamics of gas prices in Europe. Before this crisis, the BIQM, as most of the other macro-econometric models used at central banks and policy institutions, relied only on oil prices to capture the macroeconomic impacts of energy shocks, due to the high correlation between the international price of oil and that of other energy commodities (Halser et al., 2023; Box 1 in Kuike et al., 2022; Szafranek, and Rubaszek, 2024).[3] The price of these commodities diverged sensibly from the second half of 2021 and even more so with the onset of the war in Ukraine. Consequently, oil was no longer a "sufficient statistic" for keeping track of shocks to energy commodity prices and, above all, for properly assessing their implications on the forecasts of inflation. Forecast errors of inflation, as will be discussed in the paper, became significantly larger than the historical norm, as gas carries a relatively high weight in the energy basket that enters the consumer price index, due its use both for heating and energy production. Separately accounting both for the effects of gas and oil prices has thus become relevant, in order to model the macroeconomic impacts of energy shocks in an appropriate way and, in particular, to reduce the forecast errors on inflation.

The paper is structured as follows: the next section briefly presents the transmission mechanisms of energy price shocks in the BIQM. Section 3 presents and discusses the changes to the equations that account for imported energy prices, in order to separately account also for natural gas prices. In Section 4 the transmission mechanism of an energy price shock on inflation and output in BIQM is evaluated, by comparing two versions of the model, depending on whether gas prices are separately accounted for or not. Section 5 then describes in more detail how imported energy prices affect final energy consumption and prices, by accounting for the various fiscal components that enter into final gross prices. The new version of the model is then used in Section 6 to conduct some counterfactual simulations aimed at assessing the macroeconomic implications on the Italian economy of the various fiscal government measures that have been adopted in response to the recent rises in oil and gas prices. Section 7 summarizes the main results and concludes.

2. The transmission mechanism of an energy shock in the BIQM

In the BIQM, an energy shock (i.e. a change of the energy commodity price index) brings about a great number of largely simultaneous effects. In order to summarize the adjustment mechanisms set in motion by a change in energy prices we resort to a flow chart (Fig. 1), where a number of more

[1] We thank Fabio Busetti and Michele Caivano for insightful comments and suggestions.

[2] For a description of the main equations and dynamic properties of the model without a separate role for gas prices and quantities see Bulligan et al. (2017).

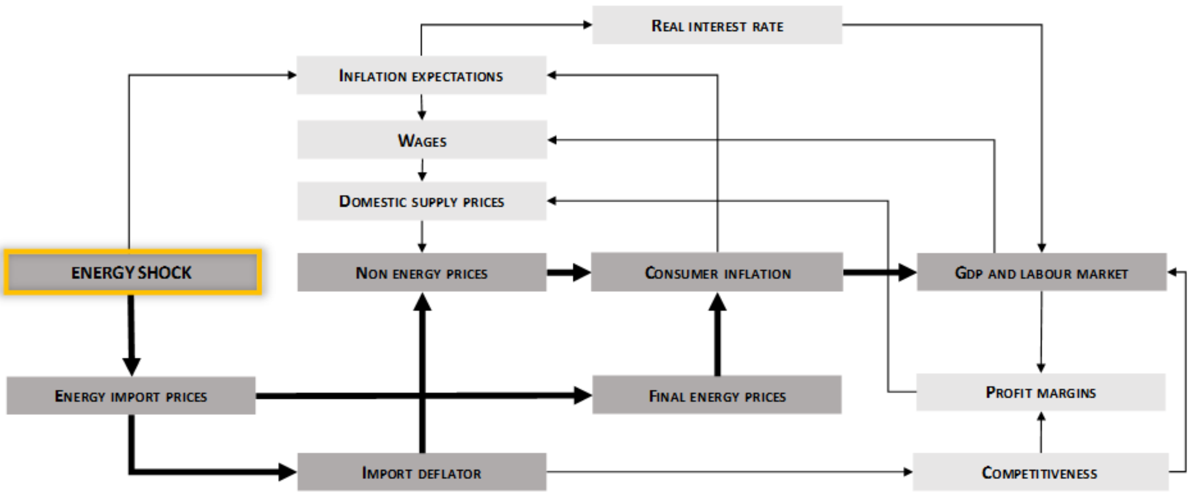
[3] Cfr. Darracq Paries, M. et al. (2021) for a thorough review and discussion of macroeconomic modelling in the Eurosystem and Ciccarelli et al. (2024) for a more recent discussion of the ongoing ECB and Eurosystem modelling agenda to align model developments with the most recent challenges and global trends, including a more detailed accounting of the energy sector and the transmission channels of energy shocks on inflation and the macroeconomy. For country-specific examples

direct or 'first-round' effects (identified by bold arrows and dark boxes in the chart) are distinguished from indirect or 'second-round' ones (thin arrows and light boxes), that are mainly associated with the endogenous feedback responses of the model.

Among *first round* effects, a shock to the energy commodity prices affects the energy imports deflator, which exerts a *direct* effect on final energy consumption prices (i.e. fuels, electricity, gas) and thus on overall consumer price inflation. This shock also influences inflation *indirectly* by affecting firms' costs (proxied in the model by the import prices deflator), and consequently all the other non-energy consumption prices. Once the energy shock has reached inflation, both directly and indirectly, it propagates to economic activity, through a wide number of channels.

Second round effects involve the adjustments induced by the response of wages and profit margins. The fluctuations of output, employment and prices borne in the 'first-round', coupled with a direct effect on short term inflation expectations[4], concur to the wage formation mechanism. Profit margins are also affected, as they likewise respond both to first-round fluctuations of output and employment and to the shift in firms' costs proxied by the change of the import prices. The movements in wages and profit margins influence supply prices, thus contributing to the further transmission of the energy shock to overall inflation and economic activity.

Figure 1. The transmission mechanism of an energy shock in the BIQM



3. Revisiting the equation of energy import prices

In the version of the BIQM in use before the eruption of the war in Ukraine, only the price of oil was included as the relevant exogenous variable for the price of imported energy commodities. Thus, oil and gas prices were not accounted for separately. Such a choice was motivated on the basis of a very high correlation between the international price of oil and that of gas (Fig. 2), by which the price of oil represented a sufficient statistic for tracking the developments in the international energy market as a whole.

[4] In the BIQM, the endogenous behaviour of (short term) inflation expectations is linked directly to the international price of energy commodities.

However, after the abrupt increase in gas prices that followed the eruption of the conflict in Ukraine, the correlation between oil and gas prices dropped significantly.[5] In view of this partial disconnect, the traditional choice to include only the oil price in the model proved rather ineffective to correctly keep track of the recent energy shock, thus leading to suboptimal forecasts (see below) and calling for amending the model.

A natural way to account for the developments in the international market of natural gas is to include the time series of the gas price in the equation of the energy commodity import prices.

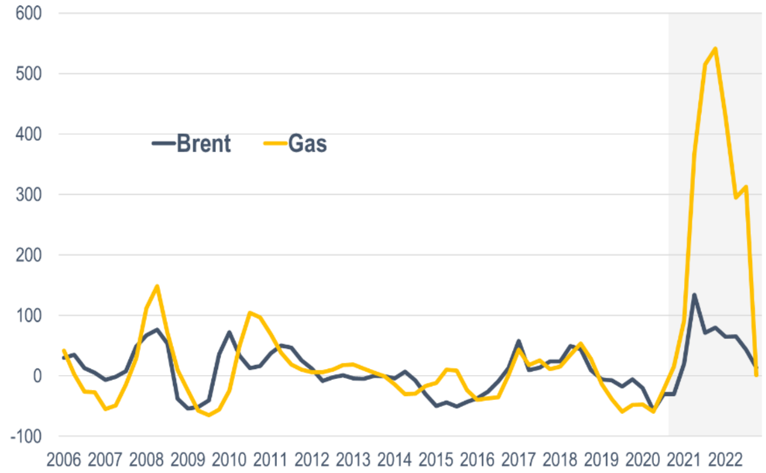
The traditional specification of the equation is expressed as an error correction model (ECM), with energy import prices (PM_t^{ENE}) set to evolve in line with the oil prices (BRT_t), which proxy for the developments in the international energy commodity market.

$$\boldsymbol{dlog(PM_t^{ENE}) = \beta_0 + \beta_1 \cdot log(PM_{t-1}^{ENE}) + \beta_2 \cdot log(BRT_{t-1}) + \beta_3 \cdot dlog(BRT_{t-1}) + dummies + \varepsilon_t} \quad (1)$$

In (1) PM^{ENE} is the deflator of Italian energy imports, while *BRT* is the US dollar price of a barrel of Brent crude oil. Notice that for the above specification to be an ECM, it must hold that $\beta_1 + \beta_2 = 0$. This restriction, which is statistically validated in the data, ensures that in the long run the ratio between energy import prices and the oil price is constant.

Figure 2. The international price of oil and gas

(YoY changes)



In its new version, the above equation has been augmented to include the Title Transfer Facility (TTF) price of natural gas, which is used as a reference for European markets. The inclusion in the equation of oil and gas prices as separate regressors is complicated by multicollinearity issues, due to the huge degree of historical correlation between the two series. For this reason, we chose to include a 'synthetic index', obtained by combining together the two relevant prices.

We define the 'synthetic index', SYN_t , the weighted average of the oil price, $BRT_t^{\$}{}_t$, and the gas price, GAS_t (expressed in dollars per barrel and dollars per barrel equivalent, respectively) as:

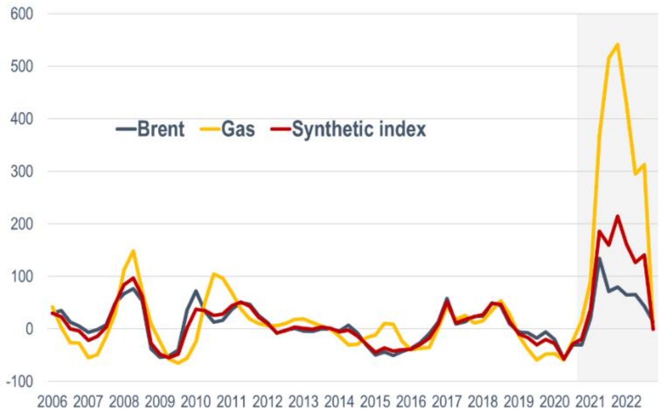
$$SYN_t = (1 - \alpha) \cdot BRT_t^{\$} + \alpha \cdot GAS_t^{\$} \quad (2)$$

[5] The correlation between the oil and gas price levels was around 0.7 on average over the 2006-20 period but it halves to 0.35 when the biennium 2021-22 is included in the sample.

where the weight, α, calibrated as the average share of imports of gas on total imports of fossil fuels, in real terms, over the five years previous to 2021 is equal to 0.4 for Italy. Before 2021, the evolution of the synthetic index is very similar to that of the oil price, while the two series differ afterwards, reflecting the dramatic surge in natural gas prices that has occurred especially in 2022 (Fig. 3).[6]

Figure 3. The international price of oil and gas and the synthetic index

(YoY changes)



The amended equation (1) accounting for the international price of gas is then the following:

$$dlog(PM_t^{ENE}) = \beta_0 + \beta_1 \cdot log(PM_{t-1}^{ENE}) + \beta_2 \cdot log(SYN_{t-1}) + \beta_3 \cdot dlog(BRT_{t-1}) + \beta_4 \cdot dlog(GAS_{t-1}^{\$}) + du's + \varepsilon_t \tag{3}$$

The coefficients β_1 and β_2 are also in this case constrained to sum up to 0 to ensure the long-run anchoring of energy imports prices dynamics to the evolution of the synthetic price index. However, in the short run the equation is augmented to account explicitly for the gas price dynamics, so as to track down separately the impact of the gas and the oil specificities, especially in cases when they are hit by idiosyncratic shocks. As in previous versions, the equation is estimated with quarterly data over the period 1975-2019 and passes the standard specification tests (a more detailed discussion of the results is reported in Appendix A).

4. The macroeconomic impact of an energy price shock in the BIQM with the new equation

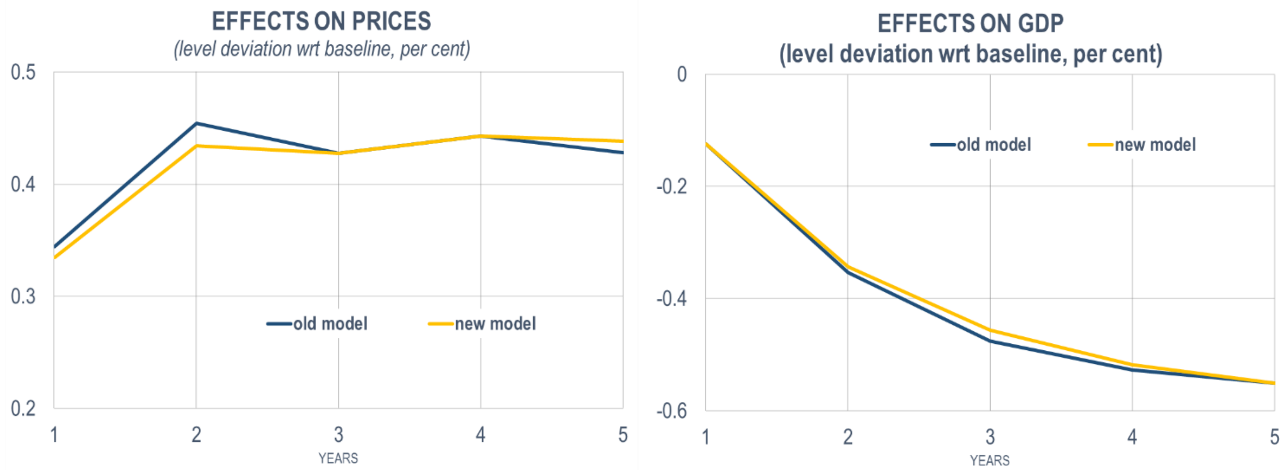
In this section we analyse how consumer prices and real GDP react to an energy price shock and compare the response of those variables with those obtained with previous versions of the BIQM, where the gas price and the synthetic index were not considered. In the new version of the model, the energy shock is designed as a 10 per cent increase both in the price of oil per barrel and in the price of gas per megawatt-hour, thus also yielding a 10 per cent rise of the synthetic index; in the former version of the model the energy shock was designed as 10 per cent increase in oil prices.[7]

[6] During the same period the price of natural gas distributed via the Henry Hub in Luoisiana, which is used as a reference for U.S. markets, exhibited increases which were much more contained compared to the TTF price.

[7] The results presented here correspond to a baseline scenario where the oil price is about 50 dollars per barrel. Higher baseline prices translate into stronger effects, as there are non-negligible nonlinearities in the model responses, which differ depending on the starting level of the oil price in the baseline, as well as on the sign of the shock. Nonlinearities related to the starting level of energy prices (and the oil price in particular) are a common feature of structural model responses. They are the result of the presence of taxes that are independent of the consumption prices (such as excise duties) as well as of the way sub-sectoral deflators are aggregated. Nonlinearities related to the sign of the shock arise from the response of profit margins in the private sector, which increase *ceteris paribus* after positive shocks to international commodity prices, thus implying a transmission of such shocks to final prices, and stay unchanged after negative shocks. The degree of non-linearity from energy prices is broadly similar in the new and in the old model.

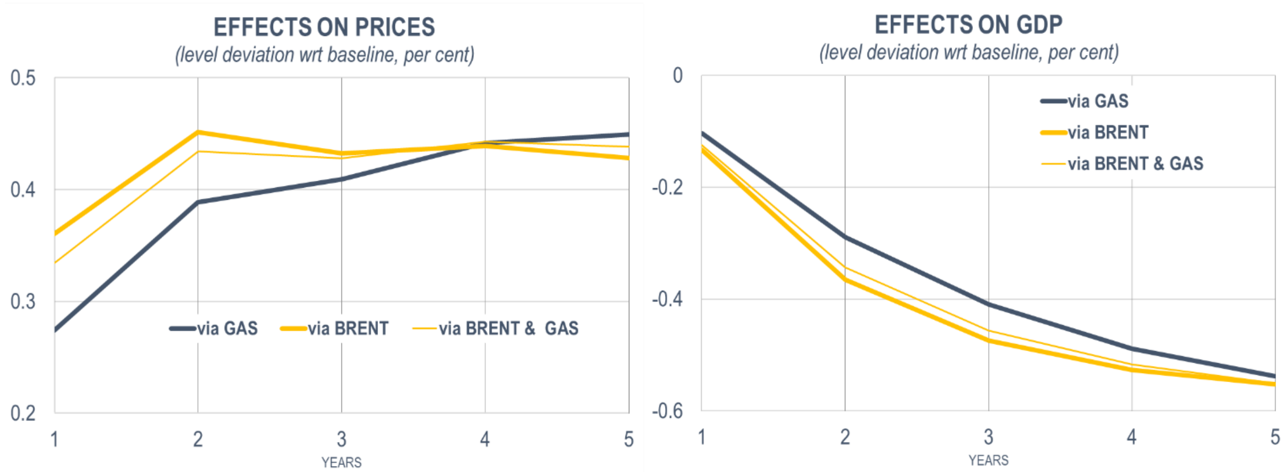
In the revised model, the reaction of consumer prices and real GDP to an energy shock triggered by both oil and gas prices is broadly similar in size and overall dynamics to that of the old model to an energy shock solely triggered by oil prices (Fig. 4). This reflects the fact that for most of the sample oil prices represent an effective proxy of energy commodity prices: the synthetic index and oil prices are indeed strongly correlated.

Figure 4. – The effects of an energy shock with the 'old' and the 'new' model



However, the features introduced with the amended version of the model allow to disentangle the role of the gas from that of the oil in driving the overall results. Simulations of a 10 per cent shock to the synthetic index, obtained either from a rise of the gas price (Fig. 5, blue bold line) – leaving the price of oil unchanged – or from a rise in the oil price (yellow bold line) – leaving the gas price unchanged – show that the transmission via oil prices is stronger on impact than via gas prices. Shocks to oil and gas prices have a comparable long-run impact: both shocks increase consumer prices by around 0.5 percentage points after 5 years. However, while the adjustment of consumer prices after an oil shock is completed within two years, the effects via gas prices tend to be more gradual, with a short-run impact that is about half that of oil prices.

Fig–ure 5. Comparing the effects of oil with respect to gas prices



On impact, the effects of gas shocks on consumer prices in our model are comparable to those documented in Alessandri and Gazzani (2023) for the euro area, but they are smaller than those found by Lopez *et al.* (2024) for Italy at medium-long term horizons.[8] However, it must be taken into account that in our framework we do not identify the sources of the gas and oil price shocks. Instead, Adolfsen *et al* (2024) show that the source of shocks matters and that the impact of the shocks might be non-linear, depending on the state of the business cycle. Our results, on the contrary, reflect the response of consumer price inflation to oil and gas price movements recorded on average across phases of the business cycles and of the energy market cycles. The fact that the impact of a shock to both oil and gas is close to that of an oil shock reflects the larger weight of oil in the synthetic index.

5. The forecasting performance of the new model in 2021-22

The rapid surge in energy prices in the biennium 2021-22 was largely unexpected and resulted in very large projection errors on consumer price dynamics (Table 1) in those years. Most of this shock reflected the surge in gas prices, which could not be accommodated by the old specification of the BIQM. This would have resulted in projection errors even if the size of the shock to oil and gas prices had been known in advance. In order to appraise to what extent the amended version of the model helps to better track the impact of the energy shock, we run a simple simulation exercise.

We consider three alternative cases: in case (a), the forecast error is computed as the difference between actual consumer price inflation and predicted inflation according the projection prepared as of January 2021, i.e. prior to the onset of the turbulences on the international market of energy commodities; this forecast error is extremely large as this projection is performed with the old version of the model, in a period of time when the swings to energy prices (both oil and gas) were not known yet. In case (b), the forecast error is computed against a simulation carried out with the old version of the model, where the actual oil price, the only relevant energy price, is included and known in advance. Finally, in case (c), the forecast error is obtained out of a simulation performed with the new version of the model, where both oil and gas are included and known in advance.

Note that the real time forecast error would have been equally large even if the new version of the model were used to perform the January 2021 projections: at the time the projection was performed, gas and oil price assumptions showed no disconnect, nor they anticipated the shock to come. The prices embedded in the futures contracts in the ten days prior to the cut-off for the publication were in both cases stable and in slight backwardation over the years 2021 and 2022.

Simulation results show that, while knowing the actual pattern of oil and gas prices would have reduced the projection errors with both models - errors in (b) and (c) are in absolute terms much smaller than those in (a) -, the gain with the new model would have been much larger than with the old model, in which only the impact of the oil price shock could be accounted for.[9]

Table 1. Forecast errors according to the different models under different set of assumptions
(percentage changes)

[8] In particular Alessandri and Gazzani (2023) highlight several structural differences between gas and oil markets – the more heavy reliance on long-term contracts in the former, the heavy regulation of the gas retail market, and the build-up of significant gas storages due to the strong seasonality in gas consumption and, finally, the tight gas-electricity link, as gas is typically the marginal and most expensive fuel for electricity generation – in accounting for the different propagation of gas price compared to oil price shocks.

[9] It is worth stressing that since the second half of 2021, when a substantial decoupling between oil and gas prices had materialized, inflation projections obtained with the old version of the BIQM were adjusted on the basis of a satellite equation for energy prices that also included gas prices among the imported energy commodities. See also Delle Monache and Pacella (2024).

		2021	2022
Forecast error old model and old assumptions (i.e. error in real time)	(a)	0.7	6.1
Forecast error old model with new assumptions	(b)	0.1	3.8
Forecast error new model with new assumptions	(c)	-0.3	0.9
Memo item:			
Consumer price inflation	(1)	1.4	6.9

(1) Inflation computed as year-on-year change in the private consumption deflator.

5. The consumption of final energy goods in the BIQM

In the BIQM several identities are included to model quantities, prices and fiscal treatment of the household consumption expenditures for the main energy commodities: electricity, gasolines, diesel fuel for transportation, diesel and gas for heating.[10]

For each energy commodity (*X)*, the real amount consumed by households (Q) is defined as a share ($WEIGHT^X$) on overall real household consumption (*CFIR*) from the National accounts[11]:

$$Q_t^X = WEIGHT^X \cdot CFIR_t \tag{4}$$

These weights affect, together with the corresponding prices and value added tax rates of the different energy sources, the nominal consumption of final energy by households, which is modelled as a weighted average of nominal consumption of all the different energy goods consumed by households.

For each energy good (*X)*, the gross consumer price index (GP^X) at time *t* is then modelled in the BIQM as a function of the price of the energy good net of taxes (NP^X), of the production taxes (PT^X) and of the value added tax rate ($VATR^X$)[12], as follows:

$$GP_t^X = (NP_t^X + PT_t^X) \cdot (1 + VATR_t^X) \tag{5}$$

Production taxes (i.e. excise duties, PT^X) and value added tax rates ($VATR^X$) have a direct impact on the Government balance sheet, as . they directly affect fiscal revenues, and on households' disposable incomes. In projection, both production taxes and the value added tax rates are exogenous and defined on the basis of the current fiscal plans of the Government. Instead, the dynamics of the net price of each good is endogenously determined according to equation (6) as a linear combination of the energy import deflator (PM^{ENE}) and of the value added deflator of the energy sector (PVA^{ENE})[13]:

$$NP_t^X = RAP_t^X \cdot \left(PM_t^{ENE} \cdot QIMPN(t) + PVA_t^{ENE} \cdot (1 - QIMPN(t))\right) \tag{6}$$

[10] Data regarding the dynamics of the prices of electricity, gasoline and natural gas for heating, all gross of taxes, have been retrieved from the subcomponents of the harmonized index of consumer prices (HICP). Data for (Super-95) gasoline fuel and diesel for automotive transportation are taken from the Weekly Commission Oil Bulletin Price Statistics. In the aggregation, we use the relative shares of consumption for each energy good in the HICP. Information about production and value added taxes for the different commodities come from the Ministry of the Economy and Finance.

[11] In absence of other information, such a share is usually projected to be constant over time.

[12] Production taxes are excise duties, i.e. indirect taxes applied to the sale or use of energy products. In the case of electricity there are no production taxes, because they are relevant in this case only for industrial uses, which are not explicitly modelled in BIQM, and for households with an extremely high level of consumption, whose relative share is negligible. Specifically, excise duties on electricity consumption do not apply on the first 150 kWh of monthly consumption. Above this threshold, excise duties in the amount of 0.0227 €/kWh are applied.

[13] Weights (*QIMPN)* are computed using the share of energy imports on the overall energy resources of the economy.

The term RAP^X is exogenous. It is updated over the forecast horizon based on the latest available information regarding the fiscal treatment of energy prices (see below for an example).

Since 2004, with the aim of redistributing part of the profits of the energy sector to the firms of the sector investing more intensively in renewable energy sources, Government introduced system charges ("oneri di sistema") for electricity and natural gas. System charges cannot be easily modelled, as they are neither a percentage of the final price of the good nor a fixed amount; moreover, their dynamics are erratic and cannot be easily linked in projection to other macroeconomic variables. Their impact on the net price is captured by RAP^X term included in equation (6), and it is projected forward judgementally on the basis of available information on Government plans. Their future impact on public finances can be included by altering the exogenous components of indirect taxes.

6. The impact of the government relief measures adopted in 2021-23

Historically, the fiscal components of gross energy prices (VAT taxes and excise duties) have been fairly stable. The share of VAT taxes has been on average 17 percent for all energy types with the exception of electricity, where it amounted on average to 9 percent (cf. grey bars in the figures in Appendix B). The share of production taxes (i.e. excise duties) has ranged from 17 percent for natural gas to around 46 percent for gasoline (cf. orange bars).

Government measures adopted to cushion the surge in gas and electricity prices have significantly altered the historical shares of the various components of gross prices, thus affecting final energy prices paid by households and firms.[14] These temporary measures were in place from 2021 Q3 until 2023 Q4 and directly or indirectly targeted gas, petrol and electricity bills. The main measures involved a cut in VAT rates (for gas), a reduction in excise duties (on petrol and diesel prices) and a slashing of system charges for electricity and gas (see Table 2).[15] Other measures, aimed at mitigating the impact of the rise in final energy prices for both households and firms comprised a cut in social security contributions for low-income workers and lower local business taxes and direct taxes paid by energy-intensive corporations (see "Other measures" under the header *Revenue measures* in Table 2). All these revenue measures amounted approximately to 0.3, 1.4 and 0.4 percentage points of nominal GDP in 2021, 2022 and 2023 respectively.

Table 2. The size of government measures on final energy prices (billions of euros)

[14] The figures in the Appendix depict how some of these measures (i.e. untargeted price measures), which differ in the timing of implementation depending on the particular energy type, have affected the main gross price components.

[15] Descriptions of the government relief measures are also included in the Bank of Italy 2022 and 2023 Annual Reports. The July 2022 Economic Bulletin also includes an evaluation of their impacts on different income groups in the box "The distributive effects of inflation and government countermeasures".

		2021	2022	2023
Revenue measures	(1)	-5088	-27404	-8599
of which:				
- VAT cut on gas and electricity bills		-608	-3,267	-2,713
- Excise duties on fuels cut		n.a.	-8,306	n.a.
- System charges cut		-4,480	-12,097	-5,796
- Social security contributions cut		n.a.	-3,734	-90
- Other	(2)	n.a.	200	523
Memo:				
Total revenue measures as a percentage of GDP		*0.3*	*1.4*	*0.4*
Expenditure measures		450	27,963	9,238
of which:				
- Tax credits for firms		n.a.	12,909	6,197
- Measures supporting households' disposable income		450	15,054	3,041
- Other	(2)	0	4,100	4,235
Memo:				
Total expenditure measures as a percentage of GDP		*0.0*	*1.4*	*0.5*

(1) Negative entries denote lower revenues. (2) Include higher revenues from local business taxes and direct taxes paid by corporations due to higher profit margins realized by firms as a result of other fiscal measures related to energy; on the expenditure side the measures include resources for supporting, in the face of higher prices, government investment spending, and the purchases by various public authorities of gas and healthcare services.

On the expenditure side the most relevant measures included tax credits for firms and a strengthening of social bonuses and transfers to households. Together with some residual interventions, total higher energy-related expenditure measures amounted to approximately 1.4 percentage points of nominal GDP in 2022 and 0.5 percentage points in 2023.

Counterfactual simulations in BIQM accounting for all the government measures that have been enacted (Table 3) show that in their absence consumer price inflation, as measured by the change in the private consumption deflator, would have been higher by 0.3 percentage points in 2021 and by 1.9 percentage points in 2022, while it would have been 1 percentage point below its actual outturn in 2023, when most of these measured have been progressively phased out. The effects on GDP are mostly concentrated in 2022 and 2023, when these measures supported GDP growth by 1.2 and 0.5 percentage points respectively.

Table 3. The macroeconomic impacts of government measures on final energy prices (1)

(percentage points deviations from historical values)

		CPI inflation			GDP growth		
		2021	2022	2023	2021	2022	2023
Untargeted measures		-0.3	-1.9	0.9	0.0	0.7	0.3
of which:							
- VAT cut on gas and electricity bills		-0.1	-0.5	-0.1	0.0	0.2	0.1
- Excise duties on fuels cut	(2)	n.a.	-0.6	0.5	n.a.	0.2	0.0
- System charges cut	(2)	-0.2	-0.8	0.5	0.0	0.4	0.2
Other measures:		0.0	0.0	0.1	0.0	0.5	0.2
of which:							
- Tax credits for firms	(3)	n.a.	0.0	0.1	n.a.	0.3	0.1
- Measures supporting households' disposable income	(4)	0.0	0.0	0.0	0.0	0.2	0.1
- Residual measures	(5)	n.a.	0.0	0.0	n.a.	0.0	0.0
Historical values		1.9	8.7	5.9	8.3	3.9	0.7
Historical values net of all fiscal measures		*2.2*	*10.6*	*4.9*	*8.2*	*2.7*	*0.2*

(1) Fiscal measures considered include both (targeted and untargeted) price and income support measures for households and firms. Numbers in the table measure the impacts assuming a counterfactual scenario in which the reported measures were not adopted. (2) Untargeted price measures: VAT rate on final gas prices reduced from 22% to 5% in 2021 Q4 – 2023 Q4; reduction in excise duties on fuels (March 2022 – December 2022); reduction (2021 Q4 – 2022 Q1) and subsequent temporary elimination (2022 Q2 – 2023 Q4) of system charges on final gas prices; reduction (2021 Q3) and subsequent temporary elimination (2021 Q4 – 2023 Q1) of system charges on final electricity prices. (3) Include both targeted and untargeted income support measures for firms. (4) Include both targeted price and income support measures for households (e.g. cut in social security contributions); also included are the strengthening of "social bonuses". (5) Include other residual untargeted price and income support measures and general fiscal measures. See also "Other measures" in table 2 reporting the sizes of the different measures.

Note that while untargeted price measures had significant effects on inflation and GDP growth rates, all other measures adopted had barely any effect on inflation rates, while they exerted significant effects on GDP growth in 2022.[16] A note of caution is warranted with respect to the effects on inflation rates of tax credits for firms, which in the table below are essentially nil. Some of these tax credits, instead of being retained in terms of higher profits by firms – this is the only channel considered in BIQM – may have instead been transferred by firms on the price of final goods and services, thus supporting households' purchasing power. While the impacts on GDP growth would essentially be the same – both higher firm profits and lower final goods prices support the private sector disposable incomes in BIQM – the impacts on headline inflation rates would turn out to be higher if tax credits were partly translated into lower prices paid by consumers. Also note that many of these measures – especially the untargeted price measures shown in the upper half of Table 3 – were progressively wound down in 2023 as energy prices on international markets retraced from the peak levels they had reached in 2022 H2. As such in 2023 the unwinding of these measures had offsetting base effects by approximately 1 percentage points on average on inflation. Finally, the table includes also a group of

[16] These results are in line with the evidence documenting that the funding allocated and earmarked for households and firms by EU governments has been largely tailored towards untargeted price-distorting measures compared to targeted income-supporting measures. See, e.g., the regularly update dataset on national fiscal policy responses to the energy crisis in Sgaravatti, et al. (2021) 'National policies to shield consumers from rising energy prices', Bruegel Datasets, first published 4 November 2021, available at https://www.bruegel.org/dataset/national-policies-shield-consumers-rising-energy-prices.

measures – Residual measures – which comprise several measures that were mainly supporting the purchases of goods and services by public authorities in the face of higher prices for these same goods and services. As such these residual measures only affected the GDP deflator (not reported), but had otherwise no effects on GDP growth and headline inflation rates.

7. Conclusions

This paper has presented an extension of the Bank of Italy quarterly econometric model (BIQM) aimed at adequately capturing the direct and indirect inflationary and macroeconomic effects of the extraordinary increases in energy prices, by modelling gas and oil prices separately.

Two main changes have been therefore introduced in BIQM. First, international gas prices have been separately incorporated among the prices of imported energy. Second, final energy consumption prices and quantities have been enriched to include explicitly the final consumption and (gross) price of gas, separately from those of the other energy sources.

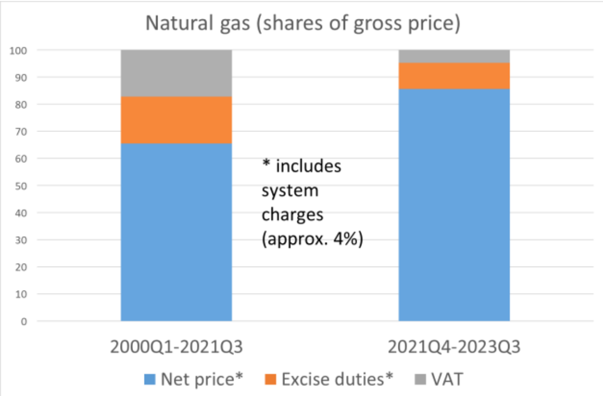
The two changes improve the ability of BIQM to properly account for the macroeconomic impacts of energy shocks and to evaluate the effects of the governments' relief measures adopted to counter the macroeconomic consequences of the spikes in the energy prices. Accounting also for international gas prices, in addition to oil prices, sensibly improves the forecasting performance of the model. The two changes permit assessing the impact of the governments' measures adopted between 2021 and 2023. These measures have reduced inflation by around two percentage points and lifted real GDP growth by slightly more than one percentage at the height of the energy crisis in 2022.

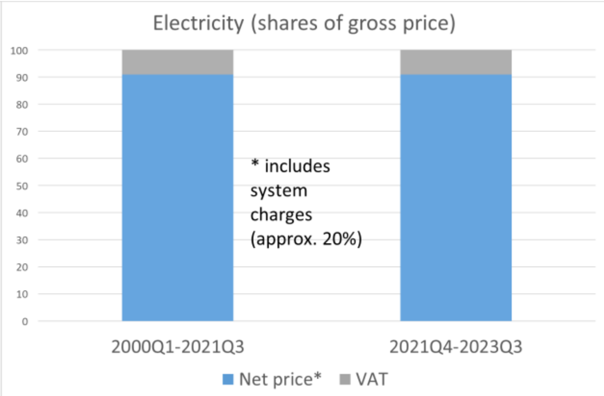
Appendix A – Estimation results for the energy import deflator equation

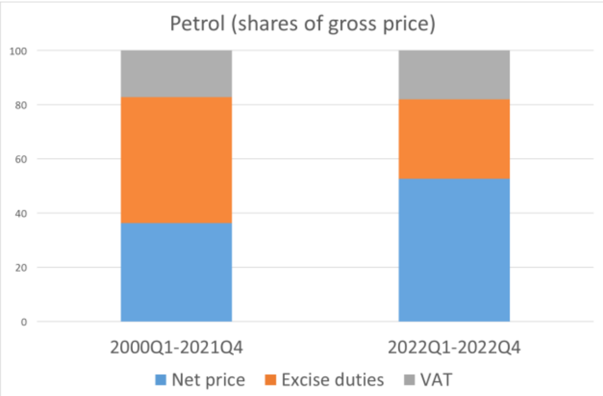
Dependent variable: log of energy import prices

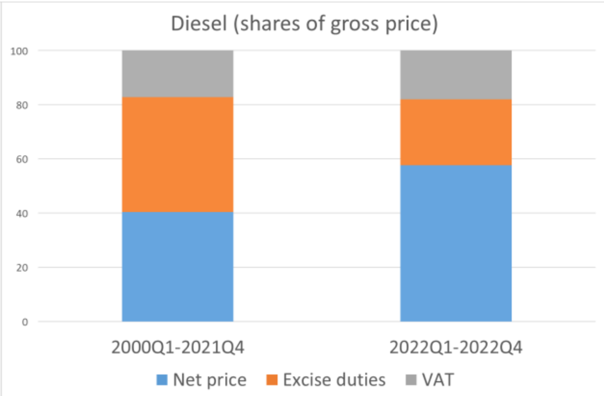
		Traditional specification	Novel specification
constant	C(0)	-0.4342 *(-4.263)*	-0.7195 *(-5.8511)*
lagged dependent variable (t-1)	C(1)	1.1493 *(19.565)*	0.6918 *(10.876)*
lagged dependent variable (t-2)	C(2)	-0.2623 *(-5.8881)*	0.1119 *(2.1307)*
log brent	C(3)	0.5151 *(17.396)*	
log brent (t-1)	C(4)	-0.4020 *(-9.9783)*	
log synthetic index	C(5)		0.5518 *(21.486)*
log synthetic index(t-1)	C(6)		-0.3555 *(-8.5488)*
dlog(gas)*$du_{post\ 2006}$	C(7)		0.1512 *(2.0404)*
dlog(brent)*$du_{post\ 2006}$	C(8)		0.2643 *(5.9562)*
dlog(brent)*$du_{pre\ 2006}$	C(9)		0.1545 *(3.3143)*
Restrictions :		C01 + C02 + C03 + C04 = 1	C01 + C02 + C05 + C06 = 1
R-Squared :		0.99033	0.99463
Adjusted R-Squared :		0.99017	0.99432
Durbin-Watson Statistic :		2.283	2.2266
Standard Error of Regression :		0.057553	0.042505
Mean of Dependent Variable :		-0.38425	-0.38425
Number of Observations :		180	180
Number of Degrees of Freedom :		176	169
Sample :		1975 1 2019 4	1975 1 2019 4

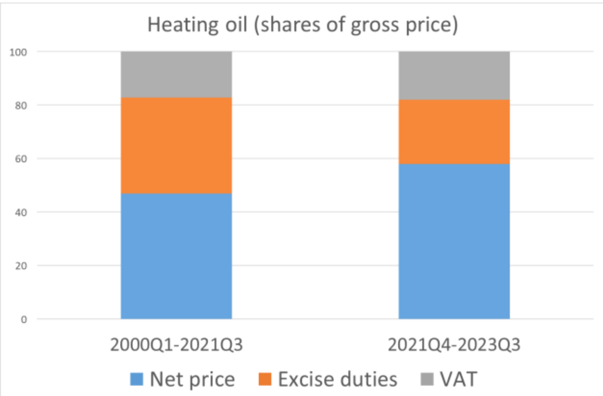
Appendix B – Shares of final gross prices of different fossil fuels











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