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Are "flexible" taxation mechanisms effective in stabilizing fuel prices? An evaluation considering wholesale fuel markets[♣]

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Abstract. This paper analyses the incidence of specific taxes in fuel markets, and exploits the findings to simulate the effects of government interventions aimed at mitigating oil price fluctuations. Several reduced-form model specifications are estimated to study tax incidence, using wholesale equilibrium prices for both gasoline and motor diesel in the Italian fuel industry over the period 1996-2007 as dependent variables. We then assess the impact on fuel prices stemming from the creation of an automatic fiscal mechanism consisting of reductions in specific taxes matching the rise in oil prices. Our evidence supports the idea that "flexible" taxation mechanisms focused only on excise taxes could not be a viable policy for stabilizing the price level in fuel markets and more complex policies (based also on *ad valorem* taxes) are needed. Alternative interventions to control prices can be designed focusing on the market structure of these industries, where Antitrust Authority could play a significant role.

Keywords: fuel markets, excise taxes, sterilization policy, antitrust policy
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Research Highlights

- "Flexible" taxation mechanisms respond automatically to oil price variations
- We first estimate the incidence of excise taxes in the Italian fuel markets
- We then assess the impact on prices of these "flexible" taxation mechanisms
- We show that these mechanisms are not effective at stabilizing prices
- We suggest that more complex policies are needed to reach this aim

1. Introduction

As a reaction to the oil price boom recorded in recent years, consumers' associations have suggested (and policy makers have experimented) the introduction of "flexible" taxation mechanisms on fuels. First experiences of these policies can be found in different countries: in the U.S., a temporary tax moratorium – i.e., a suspension of the 5% sales tax – was introduced by the Indiana and Illinois Governors as a reaction to the gasoline price peaks during summer 2000 (Doyle and Samphantharak, 2008). In France, the government modified the TIPP, the French specific tax on petroleum products, by introducing in 2000 the "TIPP flottante", i.e., a fiscal mechanism able to change the tax in accordance with crude oil price trends. The basic idea of the French socialist government in power at that time was to return consumers the excess VAT revenues caused by oil price increases by reducing the TIPP. In particular, when the reference price of crude oil (North Sea Brent) increased by more than 10% on international markets, the TIPP was automatically decreased, while it was restored when oil prices decreased. The main reason why the mechanism failed was the small number of cases when oil prices decreased, which made the "TIPP flottante" a very expensive fiscal measure. Indeed, the mechanism was abandoned in 2002 because of the large losses to government revenues.

In Italy, a policy intervention similar to the French "TIPP flottante" was included in the 2008 State Budget Law (Legge Finanziaria n. 244/2007), but it was never actually implemented as the center-left government fell after a few months. The intervention envisaged some form of flexibility in the taxation mechanisms for fuels as a response to oil price peaks: it consisted of a quarterly revision of the specific tax on fuels when the oil price was larger than the reference oil price by more than 2%. The reduction of the specific tax had to be determined by the Minister of the Economy on a case-by-case basis, and – similarly to the French solution – it aimed at compensating consumers for the larger VAT revenues. This mechanism has recently come back in the policy debate because of the surge of fuel prices caused by the civil war in Libya, the effects of which are particularly relevant in Italy because of the strong dependence of the country on the Libyan supply.

The idea of "flexible" taxation behind all these examples is very simple and easy-to-understand for consumers: in order to keep (gross) prices at a long-run equilibrium level, specific taxes should react one-to-one to observed variations in input prices. Indeed, among the various available measures, this *sterilization* of the increase in oil prices by a reduction in specific taxes on fuels seems to be one of the most popular actions (as the example of the "TIPP flottante" suggests). However, such a sterilization policy should be carefully evaluated, as for the likely impact on consumers, producers, and tax revenues. On one side, if fuel prices are (effectively) kept constant, there is a welfare enhancement for drivers and fuel consumers with respect to a situation of volatile prices. On the other side, the government needs to find different sources of tax revenues, or to correspondingly reduce public expenditures, at least in the short-run when the fiscal policy may not break even. These concerns are particularly stringent in the European fuel markets, as fuel taxes account both for a large share of the retail price in many countries (particularly in Italy, where taxes represent more than 50% of the final consumer retail price) and for a nontrivial share of government's budget revenues (about 4-5% of total revenues), and finance both Central government and Local governments expenditures.

Concerns on the impact of sterilization policies (aimed at keeping prices at a constant level) are likely to arise also because of the concentrated industrial structure of these markets, a particularly acute problem in Italy. The price of fuels has been traditionally regulated by public bodies. However, since 1994 a complete liberalization of prices for gasoline and motor diesel allowed suppliers operating in the Italian market to freely set their prices according to the international crude oil price and their operating costs (including distribution costs, retailers' margins, etc). The final consumers' price for fuels is set by retailers, while distributors often suggest a "recommended" retail price for gasoline and motor diesel. According to data provided by the Observatory on Prices and Tariffs of the Italian Ministry for Economic Development, the "recommended" retail price follows one-to-one changes in wholesale prices[1]. On several occasions, the Italian Antitrust Authority investigated the structure and the conduct of the companies operating in this industry (see AGCM, 1996, 2000, 2001, 2006, 2007), and – in a couple of instances – it established the presence of collusive conduct by the major companies in the industry aimed at controlling final consumer' prices[2].

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[1] This is not surprising given that the Italian Antitrust Authority established that the "recommended" price is defined starting from the wholesale price, adding a constant mark-up. See AGCM (1996, 2000).

[2] The fines levied on refiners by the Italian Antitrust Authority in 2000 were finally removed after the

The purpose of this paper is to contribute to the current policy debate on sterilization mechanisms, by providing some insights on the possible effects of government interventions aimed at mitigating the impact of oil price peaks. Given the absence of any data on fuel prices for consumers, in order to argue about the likely impacts on retail markets, we concentrate on wholesale markets: in particular, we consider the role of fuel specific taxes and estimate several reduced-form model specifications, which use as dependent variables the equilibrium wholesale prices for gasoline and motor diesel markets in Italy. Depending on the adopted specification and on the sub-period being considered, our results show that a 1% increase in oil price implies an increase of wholesale gasoline and diesel prices ranging between 0.1% and 0.5%. We also evaluate the incidence of specific taxes. Again depending on the chosen specification, we estimate that a 1% increase in the specific tax on gasoline and motor diesel is found to reduce wholesale fuel prices by 0.5% – 2%.

We finally simulate the impact on wholesale prices of a sterilization policy that makes specific taxes react to oil price increase. In particular, we assess both the effects of a one-to-one reduction of specific taxes in response to oil price increase, and a sterilization policy that considers the equivalence ratio between crude oil and refined fuels. Fiscal policy simulations suggest that the sterilization mechanism leads to increased fuel prices: in response to an increase in oil price, no government intervention based uniquely on specific tax reduction would guarantee constant prices for gasoline and motor diesel. Moreover, given the interplay between VAT and excise tax, our simulations point to a more rapid convergence of price variations to zero when the government does not alter much specific taxes.

The remainder of the paper is organized as follows. Next Section provides a conceptual framework and reviews the relevant literature on fuel taxes and oil prices. Section 3 describes the empirical strategy, present the data, and the main results from model estimation. We then discuss in section 4 the incidence of specific taxes on gasoline and motor diesel wholesale prices, and the implications of fiscal policies aimed at offsetting the impact of oil price increases. Section 5 concludes.

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appeal to the Administrative Court by the sanctioned companies.

2. Understanding the impact of fuel taxes on prices

While a large empirical literature study the determinants of gasoline prices and the way they react to changes in oil price (e.g., among others, Borenstein *et al*., 1997; Borenstein and Shepard, 2002; Galeotti *et al.*, 2003; Wlazlowski *et al.,* 2009), only a scant number of papers consider the effects of fuel price taxation and almost all contributions focus on the U.S. gasoline market. Our study adds to the literature by considering the impact of specific taxes on both gasoline and motor diesel markets in a European country. To understand how fuel taxation can influence equilibrium prices in fuel markets and interpret available results in the literature, it is useful to sketch a conceptual framework of a tax incidence model under imperfect competition. We borrow in particular from Stern (1987) and Delipalla and Keen (1992); for a comprehensive review of theoretical issues on tax incidence, see Fullerton and Metcalf (2002).

The theory. We consider an oligopolistic setting, where $m \geq 1$ identical wholesale distributors compete *à la* Cournot. The product is homogeneous (gasoline, or motor diesel), and it is produced at constant marginal (and average) costs $c(p^O)$, where p^O is the price of crude oil and $dc/dp^O > 0$. Each firm j maximizes the following profit function Π_j, by choosing the optimal quantity q_j:

$$\Pi_j = \left(p^N - c(p^O)\right)q_j \qquad (1)$$

where p^N is the net wholesale price of gasoline (or motor diesel). Let p^G be the gross wholesale price, s the excise tax, and v the tax rate of the Value Added Tax (VAT); it follows that:

$$p^G = \left(p^N + s\right)(1+v) \rightarrow p^N = \frac{p^G}{1+v} - s \qquad (2)$$

Substituting the definition of p^N into Equation (1), we obtain:

$$\Pi_j = \left(\frac{p^G(Q)}{1+v} - s - c(p^O)\right)q_j \qquad (3)$$

where $p^G(Q)$ is the (inverse) market demand function and $Q = \sum_{j=1}^{m} q_j$ is the aggregate production.

By differentiating Equation (3) with respect to q_j, we get the necessary first-order condition for profit maximization for firm j:

$$p^G(Q) + q_j \frac{\partial p^G}{\partial Q}\frac{\partial Q}{\partial q_j} = (s + c(p^O))(1+v) \tag{4}$$

where $\partial Q/\partial q_j$ represents each firm's conjecture about the effect of its own output change on total industry output Q. In a Cournot setting this effect is equal to one, as each firm believes the other firms' choices are independent from its own (e.g., Colangelo and Galmarini, 2001). By summing Equation (4) over the m identical producers, we obtain the equation that implicitly defines the equilibrium gross price:

$$p^G(Q)\left(1 - \frac{1}{m\varepsilon(p^G)}\right) = (s + c(p^O))(1+v) \tag{5}$$

where $\varepsilon(p^G) = -\frac{p^G}{Q}\frac{\partial Q}{\partial p^G}$ is the price elasticity of demand. We assume that the following stability condition – which also implies the second-order condition for profit maximization – holds[3]:

$$g(p^G) = 1 - \frac{1}{m\varepsilon(p^G)}(1 - \eta(p^G)) > 0 \tag{6}$$

where $\eta(p^G) = \frac{p^G}{\varepsilon(p^G)}\frac{\partial \varepsilon(p^G)}{\partial p^G}$ is the price elasticity of the elasticity of demand. By totally differentiating Equation (5), and using the stability condition (6), we get the impacts of specific taxation s and the oil price p^O on gross wholesale price p^G:

$$\frac{\partial p^G}{\partial s} = \frac{1+v}{g(p^G)} \; ; \; \frac{\partial p^G}{\partial p^O} = \frac{1+v}{g(p^G)}\frac{dc}{dp^O} \tag{7}$$

In the following empirical analysis, we model the net wholesale price (for gasoline and motor diesel) as a function of the excise tax s and the oil price p^O (plus a set of additional controls). Using the relationship in (2) between gross and net prices, we can apply results in Equation (7) to the net wholesale fuel prices:

$$\frac{\partial p^N}{\partial s} = \frac{1}{1+v}\frac{\partial p^G}{\partial s} - 1 = \frac{1}{g(p^G)} - 1 \; ; \; \frac{\partial p^N}{\partial p^O} = \frac{1}{1+v}\frac{\partial p^G}{\partial p^O} = \frac{1}{g(p^G)}\frac{dc}{dp^O} \tag{8}$$

The sign of an oil price change on net wholesale fuel price is always positive, while the sign of an excise tax change can be either negative or positive, depending on the characteristics of the demand function that enter $g(p^G)$. For instance, with a linear

[3] See Stern (1987). Notice that the stability condition is obtained by differentiating the marginal revenue, i.e., the left hand side of Equation (5), with respect to q_j.

demand function, $g(p^G)>1$, hence $\frac{\partial p^N}{\partial s}<0$; while with an isoelastic demand function, $g(p^G)<1$, hence $\frac{\partial p^N}{\partial s}>0$, since taxation causes price over-shifting, i.e., $\frac{\partial p^G}{\partial s}>1$.

The model also offers a useful framework for some comparative statics analysis. When all the firms in the industry collude, the term capturing each firm's conjecture about the effect of own output change on total industry output (the term $\partial Q/\partial q_j$ in Equation (4)) is equal to *m*. It follows that the equilibrium gross price (previous Equation (5)) and the stability condition (previous Equation (6)) become respectively:

$$p^G(Q)\left(1-\frac{1}{\varepsilon(p^G)}\right)=(s+c(p^O))(1+v) \tag{9}$$

$$g(p^G)=1-\frac{1}{\varepsilon(p^G)}(1-\eta(p^G))>0 \tag{10}$$

Hence, also the first derivative in Equation (8) is influenced by the degree of collusion. In particular one can show that the impact of a change in the excise tax is higher or lower under collusion when compared to the Cournot equilibrium, depending on the elasticity of the demand function. Notice that also the derivative dp^N/dp^O is influenced by the degree of collusion, but the direction and the size of the effect critically depends on dc/dp^O in addition to the demand elasticity.

The empirical evidence. Most studies on the impact of fuel taxes on prices find that specific taxes are passed-through to a large extent to final consumers, suggesting that the demand function is quite rigid. Chouinard and Perloff (2004) study the incidence of Federal and State specific gasoline taxes in the U.S. market. They exploit a monthly panel dataset covering the 48 mainland states and the District of Columbia from March 1989 through June 1997. They observe both wholesale and retail gasoline prices and estimate a reduced-form price equation where gasoline prices are explained by a set of demand side and supply side variables, like consumers' income, vehicles per capita, oil prices, market power and taxes. They find that, while federal specific taxes are paid by both consumers and wholesalers by approximately the same share, the burden of state specific taxes falls almost exclusively on consumers. The consumer incidence is much smaller in larger states than in smaller ones. The main explanation for these findings is that the residual supply elasticity (affecting tax incidence) is greater for state than for federal taxes, and greater for small rather than for large states.

In a related paper, Chouinard and Perloff (2007) consider also the incidence of state *ad valorem* taxes. Using the same dataset and a similar estimation strategy, they find that the burden of the federal specific tax is not equally shared between consumers and wholesalers: while consumers pay about three quarters of the tax, wholesalers pay for the remaining one quarter. Almost the entire incidence of a state specific tax falls on consumers, while a 1% increase in state *ad valorem* tax results in a 1.26% increase in retail gasoline price, but it generates almost no effect on the wholesale price.

Alm *et al.* (2009) study the incidence of state excises in the U.S. retail gasoline market. They observe monthly retail prices in all 50 states over the period 1984-1999. Exploiting variations across states in the timing of tax changes, they investigate how taxes affect gasoline prices. The main finding is a complete shifting of gasoline taxes to final consumers, so that interstate differences in gasoline prices fully reflect interstate differences in gasoline taxes, once one controls for other factors that may affect gasoline prices, like crude oil prices.

Finally, Doyle and Samphantharak (2008) analyze the incidence of gasoline state sales taxes using very detailed data on daily gasoline prices at the station level in the U.S. They estimate a reduced-form price equation, where gasoline prices are regressed against a number of demand-side and cost-side variables. Exploiting a temporary tax moratorium in two states during spring 2000, the authors are able to assess gasoline price responses to changes in tax rates. Their results suggest that about 70% of tax reduction is passed on to consumers in the form of lower prices. However, when the tax is reinstated, retail prices increase by 80-100%.

Overall, then, as already emphasized above, the available evidence suggests that – at least in the U.S. – there is a large pass-through of specific taxes to final consumers. In the following sections, we provide first evidence for a European market – the Italian fuel industry – focusing on the impact of specific taxes on net wholesale prices.

3. Econometric analysis

3.1. Empirical strategy

Our aim is to study the relationship between wholesale gasoline and motor diesel prices, on one side, and oil prices and specific taxes, on the other side. From an econometric perspective, two options are available to us: the implementation of a structural model or the estimation of a reduced-form specification. The estimation of a structural model requires the formalization of the characteristics of both the demand and the supply. On the demand side (here represented by gasoline and motor diesel retailers), we need to observe market prices (*P*), total quantities (*Q*) and other exogenous demand shifters *Z*, so that $Q = D(P, Z)$. On the supply side, represented by petroleum product wholesalers, two sets of assumptions are needed: the strategic game played by the competitors and the structure of marginal costs (see Chouinard and Perloff, 2007). Let *W* be exogenous cost shifters and Λ exogenous market power shifters; we can then express marginal costs as $MC = C(W)$ and market power as $MP = M(\Lambda)$. We decided to estimate a reduced-form model specification – i.e., pricing equations where equilibrium prices are functions of exogenous demand, cost and market power shifters $P = h(Z, W, \Lambda)$ – for at least two reasons. First, we lack variation in our data. While the dependent variables and the main regressors (specific tax and oil price) vary monthly, most of the other exogenous shifters display only *annual* variation. Second, for the identification of a full structural model, observations over other dimensions would be ideal: either spatial (e.g., region level) or firm level (e.g., prices and quantities associated to each single supplier). We consider the following multiple time-series model:

$$\begin{aligned} PGAS_t &= \beta_0 + \beta_1 TAXGAS_t + \beta_2 POIL_t + X_t'\gamma + \varepsilon_t \\ PDIES_t &= \alpha_0 + \alpha_1 TAXDIES_t + \alpha_2 POIL_t + X_t'\delta + \nu_t \end{aligned} \tag{11}$$

where the wholesale prices of gasoline (*PGAS*) and diesel (*PDIES*) are simultaneously regressed on a set of independent variables. *TAX* is the specific tax, different for gasoline (*TAXGAS*) and motor diesel (*TAXDIES*), *POIL* is the C.I.F. (cost, insurance, and freight) crude oil price, while *X* is a vector collecting a set of additional covariates that we introduce to control for demand side and supply side factors that are common to both products. In all specifications we also include a set of monthly dummy variables, to capture seasonal effects in wholesale prices. With respect to the error terms, we assume that they are uncorrelated to the set of included regressors, while the contemporaneous errors can be correlated. We estimate the system of two equations in (11) by Zellner's (1962) seemingly unrelated regressions (SUR) estimator. The main advantage from this empirical strategy is a gain in efficiency with respect to the estimation of separate equations (see Creel and Farell, 1996).

Before the estimation, all variables are transformed in natural logarithm, so as to allow for nonlinear relationships between fuel prices and the regressors. Such a transformation constraints price elasticities to be constant over time. However, we find this not to be a major problem in our data as results are basically unaltered when variables are considered in absolute terms. Moreover, in some specifications we mitigate this strong assumption by interacting some variables with a set of time-specific dummies.

3.2. Data and descriptive evidence

The main data source is the *Bollettino Petrolifero* (Oil Bulletin) published by the Italian Ministry for Economic Development. We collect data for three products: gasoline (unleaded and octave rating equal to 95 RON gasoline), motor diesel, and crude oil. Gasoline and motor diesel represent the main motor vehicles fuels. For gasoline and motor diesel, we gather monthly data on wholesale prices and the specific taxes over the period January 1996 – December 2007, leading to time series of 144 observations each. Over our observed period, gasoline average monthly sales amount to approximately 1 million tonnes, while diesel monthly average sales are much larger, reaching 1.8 million tonnes. We also obtain monthly C.I.F. crude oil prices for the same time period.

The fuel industry being analyzed is characterized by a vertical structure involving three groups of actors: refiners, wholesale distributors, and downstream retailers. Refiners transform crude oil into petroleum products. Distributors receive petroleum products at their wholesale terminals and manage the distribution service to the gas stations. Finally, retailers sell products to final consumers. We concentrate on the segment where fuels (in our case unleaded gasoline and motor diesel) are delivered from the wholesale terminals to the retailers. The net wholesale price p^N we observe is defined as the price at which products are sold to the retailers: they do not include taxes (excise tax s and VAT at rate v) and retailers' profits, that are incorporated in the retail price to consumers. The price p^N is then the equilibrium price in the market where distributors and retailers meet, and includes distributors' profit margins, but it is net of specific and *ad valorem* taxes.

Table 1 reports summary statistics for the variables used in the empirical models. Wholesale prices for gasoline and diesel average 396 Euro and 393 Euro per 1000 liters, respectively. Diesel prices show some higher volatility than gasoline prices, but the two prices are strongly correlated (correlation coefficient 0.96). Specific taxes amount on average to 615 Euro per 1000 liters for gasoline and 452 Euro per 1000 liters for motor diesel; they are lower for motor diesel over the whole sample period. On average, the tax is about 1.6 times the observed gasoline price. For diesel, the specific tax amounts to 1.2 times the wholesale price. These figures are comparable to those from other Western European countries, where - according to the Eurostat data on the second semester 2006, database on Petroleum products - the burden of specific taxes on fuel prices approximately ranges between 0.9 (e.g., in Spain) and 1.6 (e.g., in the UK). Besides specific taxes, *ad valorem* taxes (VAT) contribute to increase gross prices, but cannot be considered explicitly in the empirical model, since they show very low variability across our sample period (the VAT rate is blocked at 20% from November 1997). The price of crude oil shows a very high variability, and it trends upwards throughout the whole period. On average, crude oil price over the twelve years is about 253 Euro per 1000 liters, and the standard deviation is 164.

Figures 1 and 2 illustrate the behavior of gasoline and motor diesel prices together with crude oil price and specific tax over the observed time span, from January 1996 to December 2007[4]. A number of interesting features stands out from the figures. As noted above, oil price increased over the observed time period and wholesale prices closely followed its behavior. Starting from the beginning of 2007, however, the explosive growth of oil prices was only partially followed by wholesale prices. If we interpret the distance between the oil price and the wholesale price as a proxy for refiners and distributors margins (that seems plausible given the high degree of vertical integration and vertical restrictions existing in the Italian industry), it seems that the margins reduced over time[5]. Figures 1 and 2 also allow us to distinguish three main phases in the evolution of prices. In the first period (from the beginning of our sample till approximately the end of 1998), prices were relatively low and stable and they also tended to decrease from the end of 1997. In the second phase, during 1999 and 2000, prices increased and then suddenly decreased during 2001, reaching a quite stable level during 2002 and 2003. Finally, starting from 2004, prices steadily increased. In the meanwhile, specific taxes constantly and slowly diminished. The behavior of prices will be taken into account in the following empirical analysis, where we need to discuss the

[4] All monetary amounts are deflated using the monthly consumer price index (base month: December 2007).

[5] Actually the measurement units are different: wholesale prices refer to 1000 litres of gasoline (or diesel), while oil prices refer to 1000 litres of oil.

possible presence of structural breaks, by testing parameter stability in the estimated price equations.

To enrich our understanding of the industry, following the literature (e.g., Chouinard and Perloff, 2004 and 2007; Alm *et al.,* 2009), we also collect information on the structure of the demand and supply of petroleum products. First, we consider the market share of the industry leader, ENI, whose main shareholder is the Italian Government (*LEADER*)[6]. Given the high degree of vertical integration, ENI is actually market leader in all three segments of the market: refinery, distribution, and retail sales. The figures displayed in table 1 (and the variable adopted in the estimated specification) refer to the share in the retail market (as stated by ENI in its annual *Fact Book*). The average annual share amounts to 38% but it decreased over time, also as a consequence of the divestiture of one of its main branches (IP – Italiana Petroli, acquired by API in 2005) and reached its lowest value (29%) in 2007. Second, we consider a set of variables which are informative on the size of the demand side of the market. Distributors sell gasoline and motor diesel to retailers, and an important feature of the retail industry is the number of gas stations observed in the country (*RETAIL*). Data on the yearly number of gas stations distributed over the Italian road network comes from Unione Petrolifera (De Simone, 2008), the nationwide trade organization which associates the major Italian petroleum companies: on average, 20,000 gas stations (selling both gasoline and motor diesel) were operating during the years covered by our sample; their number is however quite stable over time, and distinguishes Italy as one of the European countries with the most thick network. The total number of registered vehicles (*VEHICLES*) is also introduced in some specifications of our price model. Data are obtained from the annual report (*Annuario statistico*) elaborated by ACI (the Italian Automobile Club), a non-profit institution that represents drivers' interests and manages the Italian Register of Vehicles. On average, there are about 42 million vehicles corresponding to approximately 727 vehicles per 1000 inhabitants. Both the absolute and the relative number of vehicles increased over time, and this evidence characterizes

[6] Notice that, at least in principle, the government could intervene on fuel prices using the publicly controlled firm. In other words, it can try to stabilize the price by using a more "politically-oriented" pricing policy instead of a 'flexible' taxation mechanism. However, even if highly regulated, starting from the mid '90s ENI is quoted on Milan and New York stock exchanges, and managers need to respond also to private investors. Control stemming from stock markets could then mitigate the ability of the government in using pricing policy at the company level to stabilize fuel prices.

Italy as the country with the largest number of vehicles (per inhabitants) in Europe[7]. To control for any change in preferences and habits over the observed period, we consider the share of the population over 65 years old (*POP65*). The average yearly share of people over 65 is 19% of the whole Italian population, and it sharply increased over time. Finally, we include quarterly per capita income (measured by Gross Domestic Product, *GDP*), as an additional demand side determinant of prices. Its average value is 6,157 Euro per capita per quarter.

3.3. Estimation results

Table 2 presents the first set of estimation results. MODEL 1 refers to gasoline equation and motor diesel equation, respectively, and shows parameter estimates from our baseline specification that includes only specific tax and oil price as explanatory variables, plus controls for seasonality in prices over the year. The coefficients for specific taxation are negatively signed and statistically significant. As expected, oil price positively and significantly affects the wholesale prices for the two products. Coefficients' magnitudes are comparable across the equations and they all should be interpreted as elasticities. A one percent increase in specific tax decreases gasoline wholesale price by about 0.54% and motor diesel wholesale price by 0.60%, while a one percent increase in oil price raises gasoline and motor diesel prices by about 0.29% and 0.40%, respectively.

Given the price movements as highlighted in figures 1 and 2, we suspect the presence of some structural breaks, that we ascertain by Chow breakpoint test and CUSUM tests (sum of recursive residual test; see Brown *et al.*, 1975). These tests suggest the presence of parameter instability in the equation during the sample period. In particular, it is possible to single out two breakpoints: one at the beginning of 2001, the other at the beginning of 2004. Under the heading MODEL 2 in table 2 we report estimation results from our two baseline equations, where specific tax and oil price are interacted with a set of three dummy variables, one for each of the three periods characterizing our sample. *TAX*_T1, *TAX*_T2 and *TAX*_T3 are obtained by interacting the variable for specific tax (*TAX*) with the dummy T1 for the first period (equal to one for observations from January 1996 to December 2000), the dummy T2 for the second period (equal to one for observations from January 2001 to December 2003), and the dummy T3 for the

[7] In 2004, the number of vehicles per 1,000 inhabitants amounted to 597 in France, 625 in Germany, 577 in Spain and 530 in UK (source ACI, *Annuario statistico* 2007).

third period (from January 2004 to December 2007), respectively. Similarly, the variable for oil price (*POIL*) is interacted with the same set of dummy variables, obtaining *POIL*_T1, *POIL*_T2, and *POIL*_T3. All the interacted variables have the expected sign and are statistically significant. More interestingly, the coefficients are different across periods: a Wald test on the equality of the coefficients for specific tax and oil price is rejected for both the gasoline and the motor diesel equations. Tax and oil elasticities are larger than those from the pooled specification of MODEL 1. Moreover, they sharply decreased during the second period (2001-2003), to return to original values in the last interval.

MODEL 3 in table 2 reports an augmented specification that considers the role of both supply side and demand side factors in determining equilibrium prices. While maintaining their sign, estimated elasticities with respect to the specific tax and oil price become higher for both gasoline and motor diesel. The hypothesis of equality of these coefficients across time is still rejected by the data, confirming the existence of some structural breaks over the observed period.

The theoretical model in Section 2 predicts that the sign of the effect of oil price changes on net wholesale fuel price is always positive, while the sign of the impact of excise tax change can be either negative or positive, depending on the characteristics of the demand function (Equation (8)). The estimated negative sign for the effects of specific taxation on net wholesale fuel prices is coherent with a linear or concave demand function, implying that taxation causes price undershifting.

Moreover, from the conceptual framework above, the change in magnitude for the specific tax coefficients across the three sub-periods is consistent with the hypothesis of a change in the conduct by the firms operating in the fuel market (see Equations (9) and (10)). In particular, the theoretical model predicts that the marginal effects associated to oil price and specific taxation change their magnitudes according to the degree of collusion. The direction of this change is however *a priori* indeterminate, as it depends on the underlying demand elasticity and marginal costs, and actually becomes an empirical issue. In our case, the magnitude of the impact of specific taxation and oil price on net wholesale fuel prices decreases (in absolute value). According to the theoretical model, this change in magnitude is compatible with a decrease in the degree of collusion and, therefore, it could be explained by the role played by the Italian Antitrust Authority, that is likely to have had an influence on the collusion among firms operating in the industry. In 1999, the Antitrust Authority started an inspection process at the premises of the companies operating in the distribution of fuels. In 2000 the scrutiny process ended, and the main companies were fined for running a price cartel. Even if the fines were removed by the Administrative Court in 2001, the Antitrust Authority started other investigations on the fuel industry both in 2005 and 2007. The fear of investigations and fines may have contributed to the reduction in the degree of collusion in the industry.

Finally, the role of VAT should be taken into account in interpreting the estimated elasticities. Given the absence of variability in the VAT rate, this cannot be included in our empirical model. However, as shown in Equation (8), VAT enters the gross price p^G, that influences the effects of both the excise tax s and the oil price p^O on net wholesale price p^N. It follows that our estimated elasticities incorporate the indirect effect of the VAT burden[8]. In particular, the increase in the magnitude of the estimated parameters for specific tax and oil price may be the result of a better specification of the model, but also the (hidden) presence of VAT may amplify the incidence of oil price and specific taxation on net wholesale fuel prices.

As for the other variables included in MODEL 3, only the coefficients for *LEADER* do not have the expected positive sign. There are at least two possible explanations for this finding: on the one hand, the collinearity of *LEADER* with some additional covariates (in particular, with the number of retailers *RETAIL*, operated and owned mainly by ENI). On the other hand, the negative and significant estimate for this coefficient might also reflect the fact that ENI is still partly owned and actually controlled by the Italian Government. This ownership structure could result in a more "politically-oriented" pricing policy, which was more likely at the beginning of our sample period, when the ENI market share was much higher. The other additional variables are all significant and exhibit the expected sign, except for *GDP* in the diesel equation. All else equal, as the number of vehicles per capita increases, the prices rise. However, such a positive impact comes about at decreasing rates, for the effect of ageing population (*POP65_VEHICLES*). Indeed, elderly people are expected to drive less and to be more price sensitive, and an ageing population has negative effects on petroleum products' prices (working through a reduction in fuel demand). A one percent increase in the

[8] The VAT burden is given by $(p^N+s)v$. We gratefully acknowledge one referee for suggesting this interpretation.

number of gas stations is found to increase gasoline and motor diesel prices by approximately 1.7-1.8%. This is a quite strong result that can be interpreted on a number of grounds. The retailers represent in our model the "consumers" of the distributors, which set wholesale prices. It is therefore intuitive that a larger demand increases equilibrium prices, all else equal. However, the Italian Antitrust Authority pointed out that the number of retailers is too high, and this causes inefficiencies and higher prices to consumers (AGCM, 1996). These inefficiencies are even more harmful – as for price competition – since the industry is strongly vertically integrated and the same actors (refiners and distributors) control most of the retailers, through direct ownership of the stations or under a franchise agreement. It follows that the positive impact of the variable *RETAIL* on gasoline and motor diesel prices is also due to market power that wholesalers enjoy as long as they control the management (i.e., the pricing) at the station level. Finally, the sign of *GDP* suggests a positive relationship between motor fuel prices and income, especially in the gasoline equation.

Robustness checks. Table 3 addresses the potential econometric issues arising from the endogeneity of our specific tax measure. If specific taxes move together with some of the unobserved determinants of fuel prices, the endogeneity concern may be serious. This is exactly what can happen in the presence of "flexible" taxation mechanism: policy makers may decide to decrease taxes when oil price increases, making the tax measure simultaneously determined with our dependent variable. We are unaware of any explicit policy of this kind *effectively* implemented in Italy. Most changes in specific taxes over our sampled time period were motivated by the EU harmonization requirements of excise duty structures and rates in EU countries, in accordance with Council Directive 1992/81/EC (and all its successive modifications, as Council Directive 2003/96/EC).

However, to control for the potential issue of endogeneity, we re-estimate MODEL 1, MODEL 2, and MODEL 3 in table 3 by using a three-stage least squares procedure (3SLS), using the specific tax rates for ethyl alcohol, other alcoholic products, and beer as exogenous instrumental variables for gasoline and diesel specific taxes (table 1 reports some descriptive evidence on the instrumental variables). We expect these variables to be correlated with fuel specific taxes, as all excise duties are regulated by the EU and must satisfy a number of harmonization requirements; but, at the same time, specific taxes on alcohol are exogenous with respect to the unobserved sterilization policy determinants in our main equation. The first stage regressions seem to support our strategy, as the exogenous instrumental variables are relevant according to statistically significant coefficient estimates and the F-test on excluded instruments (Staiger and Stock, 1997).[9] 3SLS parameter estimates for the oil price are always positive and significant and their magnitude is comparable to that from SUR specifications, reproducing also the pattern of larger coefficients for the first and the third period (MODELS 2-IV and 3-IV). Estimates for specific tax coefficients are lower in magnitude for MODEL 2-IV and higher for MODEL 3-IV, if compared to the results in table 2. Moreover, in the motor diesel equation of MODELS 1-IV and 2-IV, the tax measure is never statistically significant. Wald tests on the equality of specific tax coefficients in the three sub-periods is rejected for both gasoline and diesel. Finally, also for the impact of the additional supply side and demand side factors, the evidence is quite similar to the results obtained for MODEL 3 in table 2.

4. Policy analysis

4.1. Tax incidence

Table 4 offers some insights on the effect of specific tax on predicted gasoline and motor diesel wholesale prices. Using estimation results from MODEL 1 and 3 (i.e., the simplest and the richest specifications, respectively) we compare two sets of predicted prices:

- the predicted (gasoline and diesel) prices when all variables are set at their sample mean values, $\hat{P}_0\left(\overline{TAX};\overline{POIL};\overline{X}\right)$;
- the predicted (gasoline and diesel) prices when all variables are set at their sample mean values while the tax measure is increased by one standard deviation σ, $\hat{P}_1\left(\overline{TAX}+\sigma;\overline{POIL};\overline{X}\right)$;

where $\overline{TAX}$, $\overline{POIL}$ and $\overline{X}$ are the sample mean values for specific tax, oil price and any other regressors included in the model, respectively (see table 1 for the descriptive statistics).

In table 4, the row named MODEL 1 shows the percentage change in predicted prices for gasoline and diesel as a consequence of a one standard deviation increase in the mean

9 The results from first stage regressions are available from the authors upon request.

specific tax. MODEL 1 is our baseline specification, where a single coefficient is estimated for specific tax and oil price (first two columns of table 2). According to these estimates, we find that gasoline and motor diesel prices decrease by 2.7% and 2.9% respectively: a one standard deviation increase in specific tax – which amounts to about a 5% increase – is expected to reduce wholesale fuel prices by about 3%.

When we allow for differing coefficients across sub-periods, our estimated effects vary significantly in magnitude according to the time period. Under MODEL 3, where all the additional regressors are considered, tax shifting on producers is remarkably higher for both gasoline and diesel products. A one standard deviation increase in specific tax results in approximately a 10% gasoline price reduction in periods T1 and T3, while in the sub-period T2 the price reduction is lower (about 9%). Similar evidence is found for motor diesel prices: price decreases by 9% in periods T1 and T3, and by 8% in sub-period T2. Given the Italian Antitrust Authority intervention at the end of year 2000, we can extend the explanation for the behaviour of tax coefficients also to these trends. Interestingly, our findings highlight a sort of positive correlation between the effectiveness of Antitrust Authority to contrast companies' market power and the ability of fuel producers to shift specific taxes onto consumers. When, following the intervention by Antitrust Authority, the degree of collusion reduces (and the mark-up on crude oil price reduces[10]), wholesalers seem to be able to increase their pass-through of the excise to final consumers, since price reductions corresponding to a given tax increase are lower in absolute value. This suggests the likely existence of "behavioral pricing" policies among producers (e.g., Rotemberg, 2008): reduction in rents (due to Antitrust) is compensated by an increase in pass-through, which reduces (as a partial "compensation" to consumers) when mark-up increases.

4.2. Fiscal policy simulation

Having provided some insights on tax incidence, our next step is to simulate the impact on prices following the introduction of "flexible" taxation mechanisms on fuel products, which has been suggested by consumers' associations, and (somewhat) experimented in other countries. Among the suggested measures, the sterilization of the oil price rise

[10] Indeed, fuel price reaction to one standard deviation increase in crude oil price reduces from +25-27% to only +12%, for gasoline, and from +28-29% to only 10%, for diesel, moving from periods T1 and T3 to period T2.

through a one-to-one reduction in fuel specific taxes seems to be one of the most popular actions. A complete evaluation of the welfare impact (on producers, consumers, State and regional finances, etc) is clearly beyond the scope of the paper. Here we concentrate on evaluating the impact of sterilization policies on fuel prices in the short-run.

On the supply side, tax cuts as a reaction to oil price acceleration may have ambiguous effects. A very simple doubt can emerge by considering the asymmetric fuel price responses to variations in oil price, often identified as "rockets" when oil prices go up, and as "feathers" when oil prices go down (e.g., Galeotti et al., 2003)[11]. Our aim is just to give some insights on the likely effects of sterilization policies using our estimation results. First, in our model the supply is represented by fuel distributors, while retailers are the demand side of the market. Second, in the absence of sterilization measures by the government, the effects of an increase in oil price can be computed starting from our estimation results. All variables are in natural logarithm, so that estimated coefficients can be directly interpreted as price elasticities. Under the simplest specification (MODEL 1, table 2), a one percent increase in crude oil price brings about a 0.3% increase in gasoline price and a 0.4% increase in diesel wholesale price. Under MODEL 3 (the richest model), in period T1 and period T3, a one percent increase in oil price causes higher gasoline and diesel prices by approximately 0.5%, while in the intermediate period T2, the magnitude drops to 0.2%. This implies that, depending on the adopted specification, the impact of a 1% increase in oil price may result in a rise in fuels' price ranging between 0.2% and 0.5%.

Table 5 shows the predicted effects from a sterilization policy. We present results on predicted gasoline and diesel prices from three model specifications under three possible situations[12]:

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[11] We experimented with a number of empirical specifications that could account for the asymmetric response of fuel prices to oil price changes and we found only weak evidence of such asymmetry in price reactions. In particular the variable *POIL* was interacted with two dummy variables, one for oil price increases and one for oil price decreases. For our baseline model (MODEL 1 in table 2), we find the elasticities of fuel prices to oil prices to be always positive, but they are not significantly different whether the oil price has increased or decreased. For example, in the gasoline equation, the estimated coefficient for *POIL* interacted with the dummy for oil price growth is 0.295, while the estimated coefficient for *POIL* interacted with the dummy for oil price drop is 0.300. A Wald test on the equality of the two coefficients does not reject the null hypothesis at conventional levels for both the gasoline and diesel equations. One main explanation for this result is the monthly frequency of the data. Probably higher frequency data, e.g., daily or weekly data, are needed to disclose the asymmetric response.

[12] For monthly dummies we experimented with different strategies. Results do not qualitatively change

- the predicted prices when all variables are set at their sample mean values and the mean oil price increases by 10 Euro, $\hat{P}_{before}\left(\overline{TAX};\overline{POIL}+10;\overline{X}\right)$;
- the predicted prices when all variables are set at their mean values, and we subtract 10 Euro from the mean specific tax value, as an automatic fiscal policy response to sterilize the oil price increase of 10 Euro, $\hat{P}_{after\,1}\left(\overline{TAX}-10;\overline{POIL}+10;\overline{X}\right)$;
- the predicted prices when all variables are set at their mean values, and we subtract 20 Euro from the mean specific tax value, as an automatic fiscal policy response to sterilize the oil price increase of 10 Euro, $\hat{P}_{after\,2}\left(\overline{TAX}-20;\overline{POIL}+10;\overline{X}\right)$.

The last computation is motivated by the production equivalence ratio between crude oil and refined fuels (gasoline and diesel production). The U.S. Energy Information Agency reports that one barrel (42 gallons) of crude oil, when refined, yields approximately 19.6 gallons of finished motor gasoline, corresponding approximately to a two to one ratio: for each two gallons of oil, it is possible to obtain one gallon of gasoline (the ratio for motor diesel is approximately the same). We exploit this equivalence by suggesting that a 10 Euro crude oil price increase should be offset by a 20 Euro specific tax decrease on refined fuels.

This simulation should give insights on the expected impact of fiscal policies suggested in the recent debate: the creation of an automatic mechanism consisting of a reduction in specific taxes that exactly corresponds (in absolute terms) to the rise in oil price[13]. Our simulations point to a positive effect of the sterilization policy on fuel wholesale prices, which means that "sterilization" policies imply (at least partly) a direct transfer from the government to fuel distributors. In particular, under MODEL 1 a simultaneous increase in oil price by 10 Euro and a decrease in specific tax by 10 Euro[14] would result approximately in a 1% rise in fuel prices (computed as $[(\hat{P}_{after\,1}-\hat{P}_{before})/\hat{P}_{before}]$): gasoline and diesel prices go up by 3.5 Euro and 5.7 Euro, respectively (i.e.

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and we decided to present magnitudes that are computed setting the dummy for January equal to 1, while all the other monthly dummies are zero.

[13] Clearly, this kind of mechanism should also work in the opposite direction, with tax recovery when the oil price diminishes. In a strict sense, the stabilizing policy should break even in the long-run and should not pose any fiscal burden on the government. This brings to the problem of identifying the long-run equilibrium price of oil, which is out of the aim of our analysis.

[14] A ten Euro increase in oil price corresponds approximately to +3.96% variation (evaluated at the sample mean). A ten Euro decrease in gasoline specific tax is equivalent to –1.63% change, while a ten Euro decrease in motor diesel specific tax is about –2.21% (both evaluated at the sample mean).

$[\hat{P}_{after1} - \hat{P}_{before}]$). This figure is higher when we consider richer model specifications and when we concentrate on the first and the third sub-periods in our sample. Under MODEL 3, periods T1 and T3, a 10 Euro increase in oil price and a contemporaneous decrease in gasoline specific tax would produce an increase in gasoline wholesale price by about 14 Euro (14.7 and 14.2 Euro, respectively), corresponding to a 3.4% rise with respect to a situation where no fiscal intervention follows the oil price growth. The wholesale price for motor diesel is particularly sensitive to specific tax and oil price changes. The wholesale price rise ranges between 16 and 20 Euro, depending on the considered sub-period, corresponding to about 4% - 4.6% price changes. A policy that would exploit the two-to-one equivalence ratio between oil and refined fuels, would create even larger effects. Gasoline wholesale prices would increase by 1.8% - 7.1%, depending on the chosen specification and observational period; while motor diesel prices would rise by 2.8% - 9.5%.

Since the "recommended" retail price follows one-to-one changes in wholesale prices, our policy simulation based on net-of-tax wholesale prices is also informative of what happen on the gross-of-tax retail prices applied to final consumers. The gross-of-tax wholesale prices equal the sum of net-of-tax wholesale prices and the specific tax. The one-to-one policy simulation conducted for MODEL 1 suggests that the change in the gross-of-tax wholesale price for gasoline is given by the sum of the change in the wholesale net-of-tax price (+3.5 Euro) and the change in the specific tax (-10 Euro). The total change in the wholesale gross-of-tax price for gasoline is thus -6.5 Euro, while for diesel it amounts to -4.3 Euro. As gross-of-tax retail prices change one-to-one with wholesale gross-of-tax prices, the sterilization policy should *benefit* consumers. However, the fiscal policy simulation for MODEL 3 – which represents our preferred specification, offering a better description of the market and its working forces – brings us to opposite conclusions. In fact, the absolute changes in wholesale net-of-tax prices are always larger than the 10 Euro specific tax reduction. This means that changes in gross-of-tax wholesale prices are always positive, ranging between +2.6 Euro and +4.7 Euro for gasoline, and +6.2 Euro and +10.2 Euro for diesel. Given the complete pass-through of these changes to gross-of-tax retail prices, the sterilization policy is found to be *harmful* for final consumers. On the whole, price increases are quite large, especially for motor diesel and in the first and last time intervals of our sample. As implied by previous empirical studies reviewed in Section 2, a possible explanation may be the rigidity of the demand function. Demand for fuels is quite rigid, and elasticity is probably even lower for diesel that is more often used by professional drivers, such as trucks or bus companies. A steeper demand curve intensifies the effects of a sterilization policy leading to larger suppliers' net prices, and to larger retail gross-of-tax prices.

4.3. Toward the optimal policy

An obvious extension to the analysis of fiscal policy simulations is the search for the 'optimal policy', i.e. the change in the specific tax that leaves the net wholesale price of fuels unchanged after an oil price increase. To reach this aim, one needs to recognize the key role played by VAT, that interacts both with the marginal effects of specific tax and oil price. Unfortunately we are not able to disentangle the role of VAT from our estimated coefficients for *POIL* and *TAX*, hence we need to make explicit hypotheses on the VAT coefficients. Figure 3 shows a set of results where the difference between the prices of fuel before and after the sterilization is related to a set of likely (but unknown) coefficients for the VAT burden[15]. The underlying hypothesis is that the 'optimal policy' crucially depends on how the VAT burden enters the pricing equations in (11). Figure 3 shows that results actually depend on the magnitude of the VAT burden affecting the impact of specific tax and oil price.

Following the theoretical model outlined above, and the estimated coefficients for *POIL* and *TAX*, we derive a set of values for the implicit VAT coefficient compatible with the stability condition in Equation (6). According to these computations, we let the VAT burden coefficient associated to the specific tax to continuously vary over the range (-1; +1) and we represent it on the x-axis of the graphs in figure 3. For the VAT coefficient associated to the oil price, we make some assumptions, setting it at level +0.5 (figures 3.a-3.d-3.g), +1 (figures 3.b-3.e-3.h), and +2 (figures 3.c-3.f-3.i).

Several interesting results emerge from this analysis. First, the difference in fuel prices without and with policy sterilization is smaller for larger values of the VAT coefficients on *TAX*, i.e., the larger is the impact of the VAT, the more the government is able to stabilize fuel prices. Second, a similar effect emerges when considering the VAT

[15] Figure 3 is based on estimated coefficients from the gasoline equation, period T1, MODEL 3 in table 2. Similar results are obtained using estimated coefficients from the diesel equation or for different sub-periods.

coefficient on *POIL*: the larger the coefficient, the flatter is the curve. Third, we also checked for the effect of the change in the specific tax; in particular, we experimented with three sterilization policies consisting of a reduction of 5 Euros (figures 3.a-3.b-3.c), 10 Euros (figures 3.d-3.e-3.f) and 15 Euros (figures 3.g-3.h-3.i) as a reaction to a 10 Euros increase in the price of oil. All else equal, the speed of convergence to a zero price difference for fuels is higher when the specific taxation varies *less*. Hence the government would do better in no intervening than in implementing 'flexible' tax measures.

5. Concluding remarks

In this paper we study the incidence of specific taxes in the Italian fuel markets, and exploit these findings to simulate the impact of fiscal policies aimed at mitigating oil price fluctuations. We estimate a number of reduced-form model specifications, using the equilibrium wholesale prices for gasoline and motor diesel over the period 1996-2007 as dependent variables, and a set of demand side and supply side variables – including oil price and fuel specific tax – as price determinants. We then compute the effects on fuel prices stemming from an automatic fiscal mechanism consisting of reductions in specific taxes matching the rise in oil price. As originated from the political debate following the peaks in oil price observed in recent years, the sterilization of oil price increase through a reduction in specific taxes seems to be one of the most popular measures.

Starting from our richest model specification, fiscal policy simulations suggest that the sterilization mechanism leads to increased fuel prices: in response to an increase in oil price, no government intervention based uniquely on specific tax reduction would guarantee constant prices for gasoline and motor diesel. Moreover, given the interplay between VAT and excise tax, our simulations point to a more rapid convergence of price differences to zero when the government does not alter much specific taxes.

Such an evidence supports the idea that "flexible" taxation mechanisms focused only on excise taxes could not be a viable policy for stabilizing the price level in fuel markets and more complex policies (based also on *ad valorem* taxes) are needed. However, our results hint at a strong potential role of Antitrust Authority in influencing price reactions: probably, more effective policies should be focused on the supply side of these markets. Vertical integration, high market concentration and regulatory inefficiencies are some of the issues that can be successfully addressed by the policy maker in order to reduce the burden of excessive fuel prices on consumers.

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Table 1. Descriptive statistics [a]

VARIABLE DESCRIPTION	VAR. NAME	Mean	Std. Dev.	25th percentile	Median	75th percentile
Gasoline price (Euro/1000 lt.)	*PGAS*	395.89	85.76	326.02	381.66	464.72
Diesel price (Euro/1000 lt.)	*PDIES*	392.67	111.38	295.30	361.98	487.31
Crude oil price (Euro/1000 lt.)	*POIL*	252.73	164.24	129.28	196.43	356.28
Gasoline specific tax (Euro/1000 lt.)	*TAXGAS*	614.86	31.80	592.00	601.87	649.72
Diesel specific tax (Euro/1000 lt.)	*TAXDIES*	452.13	22.93	431.86	445.16	475.07
Market share of leader firm (%)	*LEADER*	38.26	6.11	33.00	38.60	43.46
Number of retailers (10^3)	*RETAIL*	20.31	0.30	20.03	20.24	20.57
Number of vehicles/population (x 1,000)	*VEHICLES*	726.72	48.47	683.89	742.54	765.27
Share of population over 65 (%)	*POP65*	18.63	0.94	17.82	18.71	19.47
Quarterly per capita GDP (Euro)	*GDP*	6,156.80	302.15	5,914.81	6,268.02	6,372.99
Ethyl alcohol specific tax (Euro/100 lt.)	*TAXALC*	771.89	36.30	744.45	778.93	802.50
Other alcoholic products specific tax (Euro/100 lt.)	*TAXOTALC*	60.67	5.04	56.80	59.84	62.03
Beer specific tax (Euro/100 lt.)	*TAXBEER*	1.81	0.29	1.62	1.71	1.79

[a] All prices are deflated using the monthly Italian consumer price index (source Istat, base month: December 2007). Number of observations 144.

Figure 1. Gasoline price, specific tax and crude oil price (variables in natural logarithm)

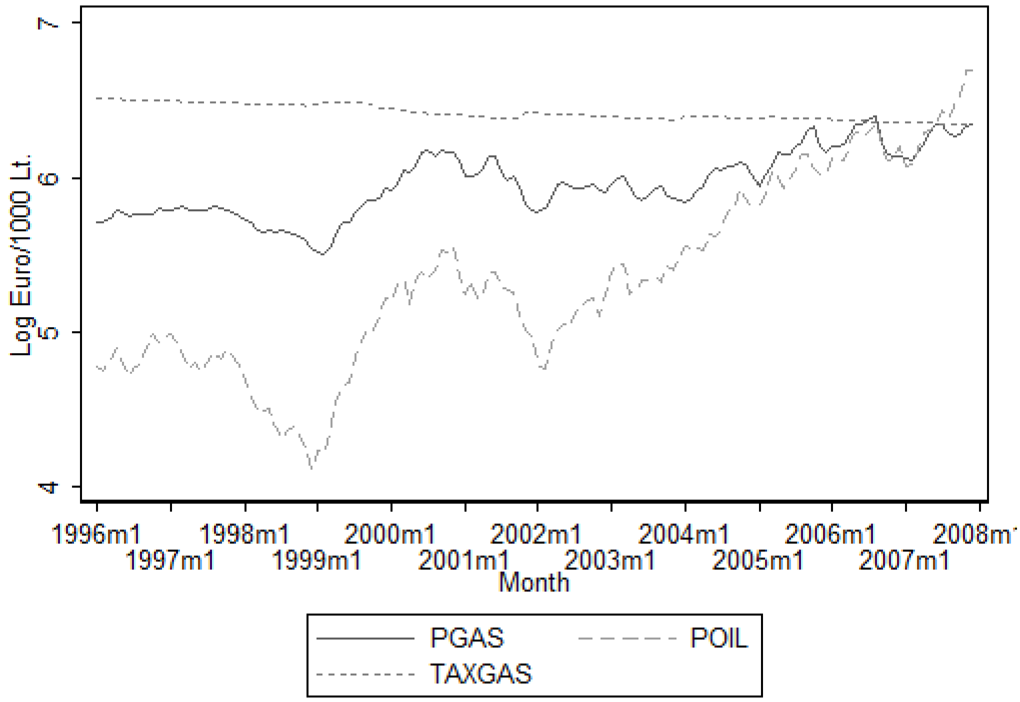


Figure 2. Motor diesel price, specific tax and crude oil price (variables in natural logarithm)

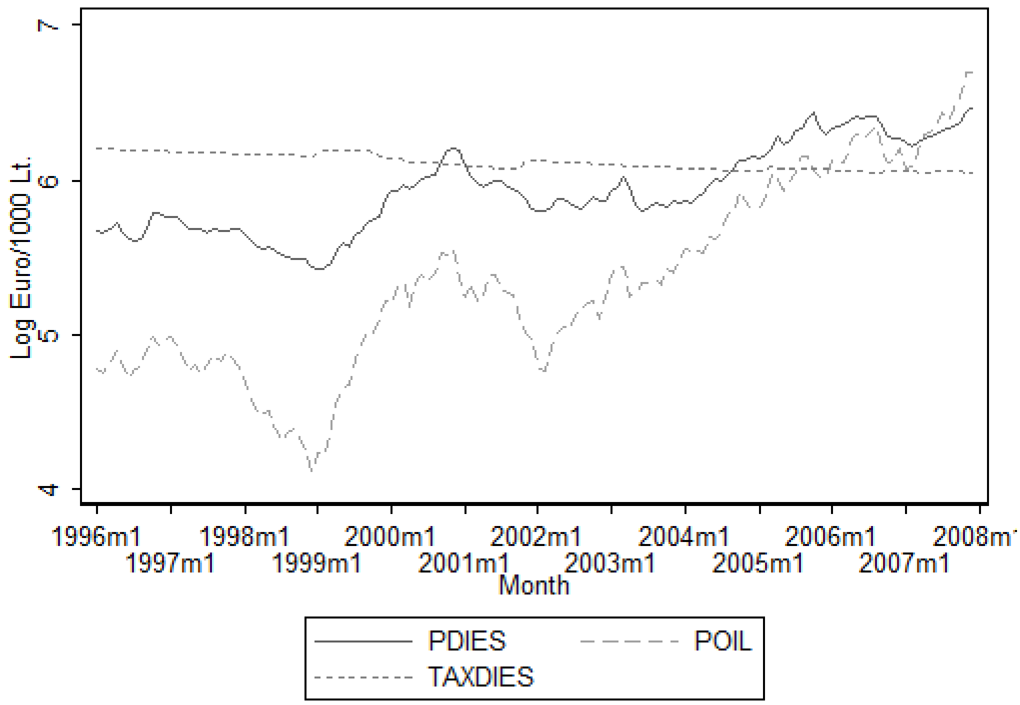


Table 2. SUR estimation: dependent variables are gasoline (*PGAS*) and diesel (*PDIES*) prices [a]

	MODEL 1		MODEL 2		MODEL 3	
Regressor	*PGAS*	*PDIES*	*PGAS*	*PDIES*	*PGAS*	*PDIES*
*TAX*_T1 [b]	-0.537***	-0.600***	-1.246***	-1.079***	-2.032***	-1.965***
	(0.19)	(0.21)	(0.24)	(0.27)	(0.40)	(0.29)
*TAX*_T2			-1.046***	-0.793***	-1.860***	-1.699***
			(0.24)	(0.27)	(0.40)	(0.29)
*TAX*_T3			-1.233***	-1.114***	-2.077***	-1.996***
			(0.24)	(0.28)	(0.40)	(0.30)
*POIL*_T1 [b]	0.287***	0.395***	0.404***	0.472***	0.431***	0.488***
	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)
*POIL*_T2			0.138***	0.124**	0.221***	0.183***
			(0.05)	(0.06)	(0.04)	(0.04)
*POIL*_T3			0.349***	0.480***	0.471***	0.511***
			(0.03)	(0.03)	(0.04)	(0.04)
LEADER					-0.384***	-1.138***
					(0.15)	(0.15)
*POP*65					-7.872***	-10.347***
					(1.81)	(1.82)
VEHICLES					29.648**	42.912***
					(11.96)	(12.16)
POP65_VEHICLE					-10.295**	-14.754***
					(4.19)	(4.26)
RETAIL					1.820**	1.658**
					(0.80)	(0.84)
GDP					1.134**	0.139
					(0.49)	(0.49)
Breusch-Pagan test of independence [p-value]	94.93 [0.00]		85.93 [0.00]		73.25 [0.00]	
Wald statistic on TAX [p-value]			25.25 [0.00]	39.60 [0.00]	28.60 [0.00]	50.94 [0.00]
Wald statistic on POIL [p-value]			29.35 [0.00]	39.89 [0.00]	28.57 [0.00]	50.19 [0.00]
Monthly dummies	Yes	Yes	Yes	Yes	Yes	Yes
Nr. of observations	144	144	144	144	144	144

[a] All variables have been transformed in natural logarithm; standard errors are reported in round brackets; significance level: *** 1%, ** 5%, *10%.

[b] Estimated coefficients for *TAX* and *POIL* in MODEL 1 refer to the impact of these variables as a whole, without considering the interaction with the set of dummy variables for sub-periods T1, T2, and T3. In MODEL 2 and 3, instead, *TAX* and *POIL* have been interacted with the three time dummies. The Wald statistic on *TAX* tests the equality of the coefficients *TAX*_T1, *TAX*_T2 and *TAX*_T3 in MODEL 2 and 3. The Wald statistic on *POIL* tests the equality of the coefficients *POIL*_T1, *POIL*_T2 and *POIL*_T3 in MODEL 2 and 3. The variable *POP65_VEHICLE* is the interaction between the variables *POP65* and *VEHICLES*.

Table 3. 3SLS estimation: dependent variables are gasoline (*PGAS*) and diesel (*PDIES*) prices. *TAX* variables are instrumented (exogenous instruments are specific taxes on ethyl alcohol, beer, and other alcoholic products) [a]

	MODEL 1-IV		MODEL 2-IV		MODEL 3-IV	
Regressor	*PGAS*	*PDIES*	*PGAS*	*PDIES*	*PGAS*	*PDIES*
*TAX*_T1 [b]	-0.518**	-0.223	-0.838***	-0.500	-2.729***	-2.721***
	(0.23)	(0.30)	(0.28)	(0.38)	(0.60)	(0.47)
*TAX*_T2			-0.639**	-0.218	-2.546***	-2.442***
			(0.28)	(0.38)	(0.59)	(0.47)
*TAX*_T3			-0.825***	-0.513	-2.768***	-2.770***
			(0.28)	(0.39)	(0.60)	(0.49)
*POIL*_T1 [b]	0.289***	0.422***	0.424***	0.501***	0.412***	0.457***
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
*POIL*_T2			0.163***	0.163***	0.186***	0.133***
			(0.05)	(0.06)	(0.05)	(0.05)
*POIL*_T3			0.371***	0.490***	0.447***	0.498***
			(0.03)	(0.03)	(0.04)	(0.04)
LEADER					-0.450***	-1.221***
					(0.15)	(0.15)
POP65					-8.525***	-11.113***
					(1.87)	(1.88)
VEHICLES					33.437***	48.100***
					(12.34)	(12.61)
POP65_VEHICLE					-11.634***	-16.521***
					(4.32)	(4.41)
RETAIL					1.604*	1.056
					(0.82)	(0.90)
GDP					0.763	-0.364
					(0.55)	(0.56)
Wald statistic on TAX [p-value]			24.82 [0.00]	34.07 [0.00]	29.50 [0.00]	53.19 [0.00]
Wald statistic on POIL [p-value]			27.87 [0.00]	33.95 [0.00]	29.82 [0.00]	52.53 [0.00]
Monthly dummies	Yes	Yes	Yes	Yes	Yes	Yes
Nr. of observations	144	144	144	144	144	144

[a] All variables have been transformed in natural logarithm; standard errors are reported in round brackets; significance level: *** 1%, ** 5%, *10%.

[b] Estimated coefficients for *TAX* and *POIL* in MODEL 1-IV refer to the impact of these variables as a whole, without considering the interaction with the set of dummy variables for sub-periods T1, T2, and T3. In MODEL 2-IV and 3-IV, instead, *TAX*, *POIL*, and all instrumental variables for *TAX* have been interacted with the three time dummies. The Wald statistic on *TAX* tests the equality of the coefficients *TAX*_T1, *TAX*_T2 and *TAX*_T3 in MODEL 2-IV and 3-IV. The Wald statistic on *POIL* tests the equality of the coefficients *POIL*_T1, *POIL*_T2 and *POIL*_T3 in MODEL 2-IV and 3-IV. The variable *POP65_VEHICLE* is the interaction between the variables *POP65* and *VEHICLES*.

Table 4. Percent change in wholesale *gasoline* and *diesel* predicted prices deriving from one standard deviation increase in specific taxes (evaluated at the sample mean values) [a]

	Gasoline price			*Diesel price*		
MODEL 1	-2.67			-2.93		
	(0.93)			(0.99)		
	Period T1	*Period T2*	*Period T3*	*Period T1*	*Period T2*	*Period T3*
MODEL 3	-9.74	-8.95	-9.94	-9.27	-8.06	-9.40
	(1.84)	(1.82)	(1.82)	(1.32)	(1.32)	(1.36)

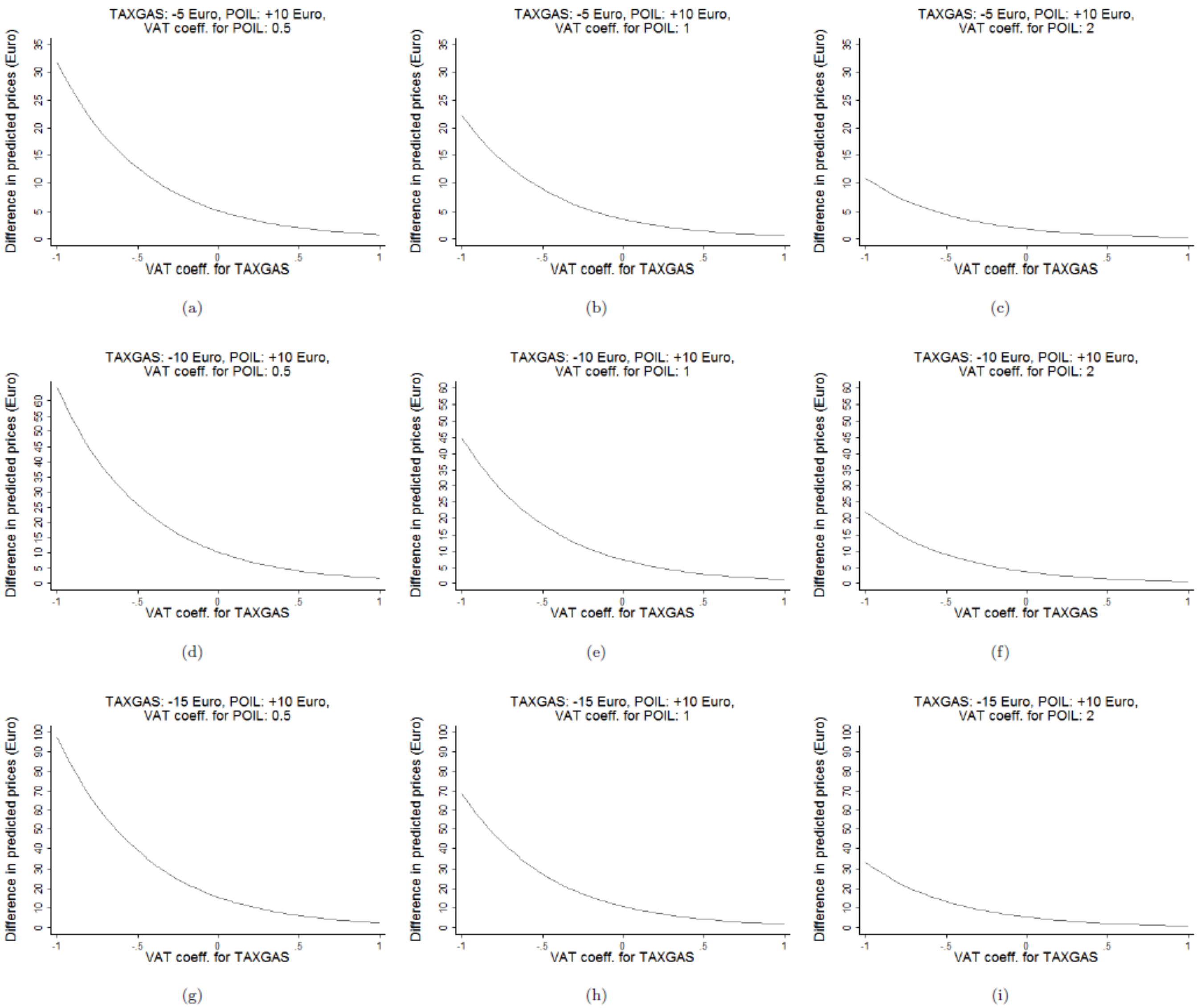
[a] Asymptotic standard errors are reported in round brackets. Computations in row named MODEL 1 (MODEL 3) are based on results from MODEL 1 (MODEL 3) in table 2. Period T1 is from January 1996 to December 2000, period T2 from January 2001 to December 2003, while period T3 goes from January 2004 to December 2007.

Table 5. Fiscal policy simulation - Impact on wholesale *gasoline* and *diesel* predicted prices deriving from two possible sterilization policies (evaluated at the sample mean values): 1] a 10 € decrease in the specific tax as a reaction to a 10 € increase in oil price (*1-to-1 sterilization*); 2] a 20 € decrease in the specific tax as a reaction to a 10 € increase in oil price (*2-to-1 sterilization*) [a]

	Gasoline price			*Diesel price*		
MODEL 1						
Predicted price: no policy intervention (Euro/1000 lt.)	393.26 (7.95)			419.30 (8.90)		
Predicted price: *1-to-1 sterilization* (Euro/1000 lt.)	396.74 (7.93)			424.97 (8.89)		
Predicted price: *2-to-1 sterilization* (Euro/1000 lt.)	400.31 (8.11)			430.84 (9.33)		
Absolute [and %] change: *1-to-1 sterilization* (Euro/1000 lt.)	3.48 [0.88%]			5.67 [1.35%]		
Absolute [and %] change: *2-to-1 sterilization* (Euro/1000 lt.)	7.05 [1.79%]			11.54 [2.75%]		
MODEL 3	*Period T1*	*Period T2*	*Period T3*	*Period T1*	*Period T2*	*Period T3*
Predicted price: no policy intervention (Euro/1000 lt.)	434.41 (9.49)	407.85 (11.42)	409.05 (10.90)	448.77 (10.04)	418.20 (11.90)	424.11 (11.61)
Predicted price: *1-to-1 sterilization* (Euro/1000 lt.)	449.13 (10.35)	420.48 (11.15)	423.22 (12.00)	468.94 (11.21)	434.40 (11.78)	443.47 (11.91)
Predicted price: *2-to-1 sterilization* (Euro/1000 lt.)	464.61 (12.07)	433.73 (11.55)	438.13 (13.77)	490.50 (13.30)	451.62 (12.34)	464.19 (12.98)
Absolute [and %] change: *1-to-1 sterilization* (Euro/1000 lt.)	14.72 [3.39%]	12.63 [3.10%]	14.17 [3.46%]	20.17 [4.49%]	16.20 [3.87%]	19.36 [4.56%]
Absolute [and %] change: *2-to-1 sterilization* (Euro/1000 lt.)	30.20 [6.95%]	25.88 [6.35%]	29.08 [7.11%]	41.73 [9.30%]	33.42 [7.99%]	40.08 [9.45%]

[a] Asymptotic standard errors are reported in round brackets. Computations under the heading MODEL 1 (MODEL 3) are based on results from MODEL 1 (MODEL 3) in table 2. Period T1 is from January 1996 to December 2000, period T2 from January 2001 to December 2003, while period T3 goes from January 2004 to December 2007.

Figure 3. Optimal sterilization policy: predicted price change as a function of VAT unknown coefficients and specific tax changes[a].



[a] The "Difference in predicted prices" is computed as the absolute difference between the predicted price with sterilization and the predicted price without sterilization, based on the estimation of the gasoline equation, period T1, MODEL 3 in table 2. The predicted price without sterilization is computed setting all variables at their sample mean values and increasing the mean oil price (*POIL*) by 10 Euro; the predicted price with sterilization is obtained by setting all variables at their mean values, increasing the mean oil price (*POIL*) by 10 Euro, and subtracting 5 Euro (panel (a) - (b) – (c)), 10 Euro (panel (d) - (e) – (f)) and 15 Euro (panel (g) - (h) – (i)) from the mean specific tax value (*TAXGAS*). The VAT rate is set equal to 20%, the VAT coefficient associated to the specific tax varies continuously from -1 to +1; the VAT coefficient associated to the oil price is set equal to +0.5 (panel (a) - (d) – (g)), +1 (panel (b) - (e) – (h)) and +2 (panel (c) - (f) – (i)).