OPEC, Gasoline Prices and the Optimal Export Tax Paradigm*

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Abstract

Building on the Optimal Export Tax model, where trade policy maximizes domestic welfare of exporting countries with monopoly power in international markets, we introduce a cheap oil model to explain the wedge between international and domestic prices of crude oil in OPEC countries, where political, as well as economic considerations affect policy decision. We empirically test this model's predictions, and find that policies affecting domestic and international oil prices in OPEC countries are, on average, consistent with the Optimal Export Tax model. Although differences of domestic oil prices among OPEC countries suggest some countries give extra weight to domestic consumers' well-being and pursue "cheap oil" polices, these differences are small.

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1 Introduction

The latest surge in crude oil prices, which began in 1991, reached a new high on July 11, 2008, when a barrel of crude oil sold for over 147 USD. This latest surge in oil prices affected some countries more than others. Consumers of super gasoline and diesel in the Organization of Petroleum Exporting Countries (henceforth, OPEC) pay a significantly lower price at the pump compared with the price paid by consumers in oil-importing countries (Metschies et al. 2007). On the other hand, although OPEC countries have monopoly power in international markets for crude oil, OPEC is not a textbook cartel; OPEC is not run by a group of profit-maximizing firms but by politicians who pursue political, as well as economic objectives.[1]

Building on these observations, we apply the export tax paradigm to explain OPEC's pricing behavior. Most of the literature on market power and political economy of trade addresses the behavior of importers using tariffs. Effective tariffs are frequently computed to monetize other protective measures. Export tax analysis is less frequent, perhaps because the multilateral system is based upon a benign mercantilist political economy (exports are good; imports are bad) that concentrates on import restrictions and by and large does not contemplate that the member states would enact restrictions on exports. But OPEC is an exporter. Therefore, we develop and apply a "cheap oil" model, which can explain the observed gap between international and domestic oil prices in OPEC countries under varying political economic assumptions. The optimal export taxes are derived for exporting countries with market power in international oil markets, and are the polar cases of the optimal tariff models developed to analyze trade policies of importing countries with market power.

Our Cheap Oil model assumes politicians place extra weight on consumer surplus from gasoline consumption. Unlike the Grossman and Helpman (1995) framework,[2] which was inspired by Democratic regimes, OPEC countries are authoritarian, and their politicians may have different political economic considerations; for example pacifying the urban middle class by providing cheap fuels. Furthermore, political economic considerations guiding politicians in OPEC countries may be different than those guiding politicians in developed countries because (1) the cost to an exporting industry due to levying an export tax is different than the benefit to an importing industry from levying a tariff, and (1) consumers in developing countries spend a higher share of their income on energy.[3]

The cheap oil policy is akin to cheap food policies, according to which governments subsidize domestic food consumption to achieve political stability and cheap labor (Schultz 1968; Johnson 1975;

[1]It has been argued that OPEC, modeled as a group of profit-maximizing firms, is a cartel (e.g., Adelman 1982; Griffin 1985). A few have also argued that OPEC is a revenue-maximizing entity (e.g., Teece 1982); that it is driven mostly by political motives (e.g., Moran 1982); or that OPEC core members behave as a dominant, profit-maximizing firm, while other members respond to a different set of incentives (e.g., Alhajji and Huettner 2000a and 2000b). See also Gately (1984).

[2]Zusman (1976) and Rausser and Zusman (1998), similar to Grossman and Helpman (1994 and 1995), assumed policy makers weigh the well being of different groups differently when setting agricultural policy.

[3]Although it is more efficient to transfer welfare to domestic consumers by combining an export tax and a consumption subsidy, we adopted the view expressed in Drazen and Limao (2008), where politicians elect to use less efficient transfer instruments to improve their bargaining position, and elected to focus only on export taxes.

Lewis 1955; among others).[4] Recent developments have demonstrated the political importance of cheap oil prices. The outcome of the 2008 election in Indonesia is likely to be affected by high oil prices (The Economist 2008); John McCain and Hilary Clinton suggested a gas tax holiday as part of their election campaigns in 2008 (Thomson Reuters 2008).

We test the hypotheses based on these models, using data on OPEC countries and on international markets for crude oil. Although the cheap oil model fits the data well, on average the extra weight placed on consumers is small. Furthermore, the political weight of different groups varies across OPEC countries. Core OPEC countries (Iran, Iraq, Kuwait, Saudi Arabia and Venezuela) place a higher weight on consumers' well-being, leading to lower oil prices.

Despite the enormous amount of research that followed the surge in oil prices during the 1970s and 1980s, OPEC's pricing behavior still elicits considerable puzzlement (Adelman 1982; Teece 1982; Moran 1982; Griffin 1985; among others). Although the majority of the literature refers to OPEC as a profit-maximizing cartel, some argue that Saudi Arabia acts as the dominant producer (Mabro, 1996; Alhajii and Huettner, 2000a and 2000b). Changes in oil prices during the 1970s are explained by changes in property rights, whereby control in OPEC countries shifted from private to public hands; namely, nationalizations occurred (Johany, 1979; Odell and Rosing, 1983). Other studies suggest political forces increased oil prices, which remained high because of capacity constraints in OPEC countries (Ezzati, 1976 and 1978; Salehi-Isfahani, 1987). We contribute to this literature by introducing an alternative conceptual framework that captures OPEC's pricing behavior. The proposed framework builds on work dating back to the middle of the 20^{th} century (Graaf 1949-50; Johnson, 1953-54; among others), which was later extended by Grossman and Helpman (1994, 1995) to include political incentives.[5] The alternative framework fits actual OPEC pricing data well. Unlike the traditional literature on OPEC's pricing behavior, we find that domestic demand significantly reduces supply for export and increases international prices.

The empirical political-economy literature supports the hypothesis that politicians place extra weight on producers' welfare when setting tariffs (Broda et al. 2008; Gawande and Bandyopadhyay 2000; Goldberg and Maggi 1999; among others).[6] The empirical findings of this paper suggest that consumers and the oil sector in OPEC countries receive, as a whole, similar weights when setting oil policy. Yet, a closer look at some OPEC countries reveals that extra weight is placed on consumers' welfare, as opposed to producers' welfare.

Although we address a non-renewable resource (Griffin and Teece 1982; Pindyck 1978; among others), we assume a static framework, which allows us to highlight the importance of monopoly power in the international oil market and explain the link between crude oil prices and gasoline prices.

[4] In addition to cheap food policies, food production is also substantially altered by export subsidies, a key factor in the failure of the WTO Ministerial Conference in Cancn in late 2003 (Peters 2008).

[5] See also Bhagwati et al. (1998).

[6] For a comprehensive survey on the topic, see Gawande and Krishna (2003).

Nevertheless, the conceptual results derived in the paper boil down to decision rules that equate marginal benefits with marginal costs, which in a more elaborated dynamic model may include user costs. Such a model, however, is beyond the scope of this paper. Furthermore, specifications used in our empirical analysis, which distinguish between OPEC countries using proven reserves, suggest that politicians in OPEC countries do not take into account inter-temporal considerations.

The conceptual framework is briefly described in Section 2. The global oil markets, as well as the importance of OPEC countries and gasoline and diesel prices at the pump are described in Section 3. The empirical analysis is presented in Section 4, and a discussion and concluding remarks are given in Section 5.

2 Modeling market power in international oil markets

Many models have been developed to forecast oil prices and to model the world oil market based on the assumption that OPEC is a profit-maximizing (firm) cartel. The predictions derived, however, perform poorly.[7] The failure of the cartel approach suggests that a non-cartel approach is needed. We now develop an alternative approach, using a theoretical static trade framework.

Assume two countries, Home (H) and Foreign (F), where following the convention used in the trade literature, country F's variables are denoted with an asterisk (*). In addition, assume two products: oil, denoted by subscript 1, and a numeraire good, denoted by subscript 0. Country H and country F are endowed, respectively, with L and L^* units of good 0. Country H produces Q units of oil, with X units sold domestically and M units sold abroad. Country F, on the other hand, exports good 0. We also assume balanced trade.

We normalize the population in each country to 1. Preferences in monetary terms for a consumer in country H are captured by the following quasi-linear utility:

$$U = C_0 + u\left(C_1\right), \tag{1}$$

where C_0 denotes the numeraire good, and where $\partial u / \partial C_1 > 0$ and $\partial^2 u / \partial C_1^2 < 0$. We normalize the price of good 0 to 1. Thus, let p denote the price of oil in H and p^* will denote the price of oil in F; the consumers' total expenditure (income) is I. With these preferences and assumptions, H's per capita inverse demand equals $\partial u / \partial C_1$. The consumer in H devotes the remainder of his total expenditure to

[7] This assumption has been used in numerous studies on the international oil market that investigated OPEC's pricing behavior in a static framework (Adelman 1982; Alhajji and Huettner, 2000a and 2000b; Dahl and Yucel, 1991; Gately, 1984; Griffin 1985; Griffin and Xiong 1997; Gulen, 1996; Horn, 2004; Loderer, 1985; among others). All those studies focused on the oil market, i.e., a partial equilibrium analysis, and asked whether the international price of crude oil was the cartel (monopoly) price. Moreover, all those papers assumed oil is extracted by profit-maximizing firms. Among these studies, only Griffin (1985) found statistical support for the cartel model.

the numeraire good, i.e., $C_0 = I - p \cdot C_1$, thereby attaining a utility level

$$V = I + CS,$$

where $CS = u(C_1) - p \cdot C_1$ is the consumer surplus from oil consumption. In equilibrium, supply equals demand, i.e., $C_1 = X$ and $C_1^* = M$. We similarly define preferences in F; namely, $V^* = I^* + CS^*$.

We consider cases in which ad valorem export taxes derive a wedge between country H's and country F's prices. Following the conventional notation used in the international trade literature, we represent this policy using the parameter $\tau > 0$, such that $p = \tau \cdot p^*$.[8] Furthermore, we maintain the assumption that trade policy revenues are re-distributed to consumers as lump-sum transfers. The export taxes generate per capita government revenue of

$$\Psi = -(\tau - 1) \cdot p^* \cdot M.$$

The oil cost function is $TC(Q) = TC(x + M)$. Its derivative, $\partial TC/\partial Q$, is the marginal cost curve, which also serves as the supply curve of a competitive industry. The cost function of a finite resource can also include user costs, which are a function of proven reserves. Because the dynamic aspects of oil extractions are beyond the scope of this paper, we remain agnostic with respect to the different cost components.

Income in country H, I, is collected from several sources. Most earn income from the endowment and all receive the same transfer from the government. In addition, a fraction α_L of the population own claims to a specific input used to extract crude oil. This fraction of the population earns $\pi = p \cdot Q - TC(Q)$ from crude oil production, and is endowed with l units of good 0. Hence, the welfare of individuals with claims to a specific input used to produce crude oil is

$$\Omega = l + \pi + \alpha_L \cdot [\Psi + CS].$$

The welfare of the rest of the economy is Γ, and is a function of endowment, profits, tariff revenues, and monetary benefit from oil consumption, i.e.,

$$\Gamma = L + \pi + [\Psi + CS].$$

We similarly define welfare in F, given F has only one source of income: endowment L^*. In other

[8] OPEC member states establish international quota; however, they do not always abide by these quotas. On the other hand, all OPEC member states subsidize domestic gasoline and diesel prices. Although OPEC member states do not explicitly impose an export tax, the empirical analysis supports the assumption that, in practice, export taxes are good proxies for OPEC pricing behavior (see Section 4): local prices are substantially lower than international prices (see Section 3). Henceforth, in our empirical analysis, we denote this difference as the export tax and do not extend the analysis to investigate the (constraint) efficiency of different instruments. Having said that, assuming politicians maximize domestic welfare and markets are competitive, the outcome derived when politicians in country H choose quantity and a consumption subsidy is identical to the outcome derived when they choose an export subsidy.

words,

$$\Gamma^* = L^* + CS^*.$$

We use this notation to compare five types of outcomes: The global optimum, where global welfare is maximized; the cartel outcome, where profits from oil production are maximized; the Optimal Export Tax model, in which H's welfare is maximized; and two political economy models, in which politicians in the oil-rich exporting countries weigh the welfare of different groups differently.

In the (nondiscriminatory) cartel model, the cartel determines the quantity produced globally. In the other models, we assume politicians choose the policy variable τ to maximize their objective function, given that quantities consumed and produced are determined by market forces and given all markets are perfectly competitive. Specifically, the models we consider include:

2.1 The global optimum

This optimum is obtained by maximizing the sum of welfare of country H and country F:

$$\underset{\tau}{Max} = \Gamma + \Gamma^*$$

As shown in numerous studies, at the global optimum export taxes equal zero and $p = p^* = \partial TC/\partial Q$. Given no-transaction costs, the oil prices in H equal the prices in F. If, in addition, firms are price takers, then prices equal the marginal cost of production.

The global optimum is not likely to occur in oil markets because a wedge between the price of oil in OPEC and the oil importing countries is observed in the data.

2.2 The cartel outcome

If, instead of maximizing global welfare, firms collude and form a cartel, then in equilibrium $\partial R/\partial Q = \partial TC/\partial Q$, where R denotes total revenues. In other words, marginal revenue equals marginal cost and $p = p^* > \partial TC/\partial Q$. Although this theory explains why international crude oil prices are higher than marginal cost, the cartel model does not explain the observed wedge.[9]

2.3 The Optimal Export Tax model

Politicians in the exporting country design the export tax to maximize the sum of its consumers' and producers' net welfare plus the export tax revenue:

$$\underset{\tau}{Max}\,\Gamma$$

[9]To this end, it is interesting to note that simulations and empirical estimations show that the international price of crude oil lies somewhere between the competitive price and the monopoly price (Griffin 1985).

The optimal allocation rule is then derived, assuming firms are price takers and the economy has monopoly power in international markets (see Fig. 1). The marginal export revenue curve, $MR_X = \partial (p^* \cdot M)/\partial M$, is added to the domestic demand curve, D_D, to yield the kink curve $D_D + MR_X$. The intersection of this curve with the supply curve of the oil sector, S, yields total oil output, Q, which results in export and domestic consumption levels, M and X, respectively. In this case, p denotes domestic price and export price $p^* > p$. To implement this policy, the export tax should equal $p^* - p$. Such a policy can also be implemented with a quota, Q, and a domestic consumption subsidy equal to $p^* - p$.[10]

Formally, the export tax τ^o is

$$\tau^o = \frac{1}{\varepsilon^*} < 0 \text{ where } \varepsilon^* = \frac{p^*}{M}\frac{\partial M}{\partial p^*} < 0.$$

As long as the markets are competitive, the resource allocation of the optimal export tax is identical to the allocation derived when policy makers in country H choose a consumption subsidy and a quantity. The optimal export tax equals the consumption subsidy.

This analysis obviously abstracts from the politics underlying the price of oil. We address this concern, borrowing from the literature on interest groups and protection, and specifically from Grossman and Helpman (1994 and 1995) and from Dixit et al. (1997).

2.4 Rich Oilmen model

This model assumes politicians maximize a linear objective function with two distinct components: the welfare of the exporting sector (in our case the oil sector), Ω, and aggregate social welfare, Γ, i.e.,

$$G = a\Gamma + \Omega, \text{ where } a \geq 0.$$

The constant $a \geq 0$ is the relative weight the government places, in its linear objective function, on aggregate welfare relative to the oil sector's welfare (if a is very small then politicians care only about the oil sector, whereas if a is very large then they care about the citizens – consumer surplus and tariff revenues). Politicians place additional weight on the oil sector's well-being, partly capturing the assumption that they value the oil sector's well-being more than its citizens.

Export tax, now, is not only a function of world import demand elasticity, but also a function of the sector's political power. Formally, politicians solve

$$\underset{\tau}{Max}\, G = a \cdot \Gamma + \Omega$$

[10] It is interesting to note that use of an export tax is in flagrant violation of the World Trade Organization agreements, to which Saudi Arabia – the country with the largest stock of proven oil reserves in the world by far – is not a party.

The equilibrium ad valorem export tax rate, then, is

$$\tau^{po} = \frac{1}{\varepsilon^*} + \frac{1-\alpha_L}{a+\alpha_L}\frac{Z}{\tilde{\varepsilon}} > \tau^o \tag{2}$$

where $Z \equiv Q/M$ and $\tilde{\varepsilon} = \frac{p^*}{(Q-X)}\frac{\partial(Q-X)}{\partial p} > 0$. The optimal political export tax τ^{po} is greater than the optimal export tax $\tau^o < 0$, and it approaches the optimal export tax τ^o as the weight placed on aggregate welfare, a, increases.

A very small part of the population is employed in the oil sector. In the oil refining industry, for example, less than 50,000 workers are employed in any OPEC country (ILO 2008). Therefore, we assume $\alpha_L = 0$, which implies that $G = a \cdot \Gamma + \pi$ and $\tau^{po} = \frac{1}{\varepsilon^*} + \frac{1}{a \cdot \tilde{\varepsilon}} Z$.

2.5 Cheap oil model

An alternative perspective to politicians' behavior assumes policy is used to subsidize oil domestically, and to preserve political stability and prevent consumer revolt. Formally, according to the alternative approach, politicians weigh consumer surplus differently than they weigh the oil producers' profits and the export tax revenues:

$$\tilde{G} = \Gamma + \gamma \cdot CS.$$

The constant γ is the relative weight politicians place on consumer surplus relative to the oil sector's welfare (if $\gamma > 0$, then the government places additional weight on consumer surplus, whereas if $\gamma < 0$, then we are back at the Rich Oilmen model according to which governments care about tax revenues and the oil sector profits more than the consumer surplus).

If, instead of maximizing G, politicians solve

$$\underset{\tau}{Max}\, \tilde{G} = \Gamma + \gamma CS,$$

then the political optimum ad valorem export tax will be

$$\tilde{\tau}^{po} = \frac{1}{\varepsilon^*} - \gamma \frac{\chi}{\tilde{\varepsilon}} < \tau^o \tag{3}$$

where $\chi = \frac{X}{M}$. Note that in contrast to the export tax derived in the Rich Oilmen model, under the Cheap Oil model, $\tilde{\tau}^{po} < \tau^o < 0$ (assuming $\gamma > 0$); politicians pursue policies that maintain cheap oil. Note that decreasing γ increases $\tilde{\tau}^{po}$ and decreases the difference $\tau^o - \tilde{\tau}^{po}$.

Although the conceptual framework focuses on one exporting country and one importing country, it can be extended to include several exporting countries, yielding an export tax structure in equilibrium that is similar to the one derived above. To simplify the exposition, we elected not to extend the conceptual framework to several exporting countries. To this end, the empirical section begins by focusing on OPEC's pricing behavior as a whole; we estimate the average pricing behavior of an OPEC country. Next, and unlike the conceptual framework derived above, the empirical analysis is extended to include differences among OPEC countries. Using these alternative empirical specifications, we offer support for our main hypothesis: OPEC's pricing behavior fits the Optimal Export Tax paradigm, while accounting for political as well as economic considerations.

3 Crude oil and OPEC

3.1 International markets for crude oil and OPEC

OPEC is an intergovernmental organization that was created at the Baghdad Conference (September 10–14, 1960) by Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela (henceforth, denoted core OPEC states). The organization started its life as a group of five oil-producing and developing countries seeking a higher share of profits in an international oil market dominated by the Seven Sisters.[11] Only when the Arab states began to gain control over oil prices and production in the 1970s, mainly through the formation of OPEC, did the Seven Sisters' influence decline. The rise of OPEC to international dominance, as its member countries took control of their domestic petroleum industries, left extraction of the crude oil in state hands.

3.2 Gasoline and diesel prices in OPEC countries

Using data collected by the Metschies et al. (2007), we computed the subsidy or tax equivalence levied on super gasoline and diesel prices at the fuel pump. The generic concept of subsidization relates to a benchmark whereby fuel pricing is commercially calculated with respect to world market prices. In this sense, subsidization takes place when the actual pump price is below the benchmark price. Because these benchmark prices are difficult to calculate with precision on paper, fuel prices are considered to be subsidized if they are below the average US price level, after deducting a highway tax, which in the United States is equal, on average, to 10 US cents per liter.

We apply a similar logic to non-petroleum- and petroleum-producing countries. Although petroleum-producing countries have their own national supplies, and therefore their low cost prices can be classified as non-subsidized prices, we reject this classification. If the volume of oil consumed domestically was sold on the world market, it would have achieved higher prices.

[11]The Seven Sisters consisted of three companies formed by the breakup, by the U.S. Government of Standard Oil, along with four other major oil companies.

The nominal subsidy/tax for super gasoline in US cents per liter, for OPEC as well as non-OPEC countries, is depicted in Fig. 2. As is evident, the average gasoline price for OPEC countries is substantially lower than the price in oil-importing countries. Moreover, nominal subsidies went up in OPEC countries, at times when crude oil prices surged (2002-2006). During the recent surge in oil prices, and in reaction to them, Saudi Arabia reduced its own fuel prices by 30% – officially out of benevolence to its own population (Metschies et al. 2007). Saudi Arabia is not a member of the World Trade Organization, and therefore is not constrained by the rules governing this institution, which restrict the use of an export subsidy. A similar pattern can be depicted for diesel prices.

Nominal super gasoline and diesel prices for OPEC, as well as non-OPEC countries are plotted in Fig. 3. The difference between the two groups is clear; the increase in prices is much larger in non-OPEC countries. Furthermore, although before 2000 that difference was stable, it began to grow at an increasing rate after 2000. It is interesting to note that the increase in prices in 2000 was attributed by the popular press to OPEC production cuts agreed upon in March 1999. Alhajji and Huettner (2000a), on the other hand, argued that low oil prices in 1998 and early 1999 led to lower upstream investment and lack of maintenance. Consequently, world oil production declined and many oil fields suffered from severe technical problems, which, in turn, lowered production capacity. We return to this point at the end of Section 4.

4 The empirical analysis

In Section 2, we illustrated, using a simple, general equilibrium trade model, that a country with monopoly power in international markets will, in the absence of a trade agreement, set low domestic prices and high international (exporting) prices. We now derive an empirical model to evaluate our hypothesis.

4.1 The empirical model

The conceptual framework depicted in Section 2 presents three alternative models to explain the observed wedge between international and domestic prices: The Optimal Export Tax, the Rich Oilmen, and the Cheap Oil models. We now empirically evaluate the three alternatives. To this end, we develop two empirical models, one that builds on Eq. (2) (i.e., the Rich Oilmen model) and the other on Eq. (3) (i.e., the Cheap Oil model). The Optimal Export Tax model is a special case of both. The discussion of the empirical analysis is developed for the Rich-Oilmen model (Eq. 2), but it also applies to the Cheap Oil model (Eq. 3).

Trefler (1993) recognized that the volume of trade may be endogenously determined with trade barriers, and Grossman and Helpman (1994) emphasized the need for incorporating it into the econometric analysis. Building on these observations, the empirical specifications include two endogenous variables - the ad valorem export tax, τ, and the export intensity, Z (i.e., the ratio of oil production to exports) - and two empirical equations - the trade tax equation (i.e., Eq. (2) in the Rich Oilmen model) and the export intensity equation, where Z is the dependent variable. Using the variable addition test devised by Wu (1973), we find that τ and Z are indeed endogenous.[12] Moreover, because the error terms of the two equations are correlated, we estimate the parameters using three-stage least-square techniques. Therefore, the empirical model used to evaluate the Rich Oilmen model is

$$\begin{aligned} \tau &= \alpha_0 + \alpha_1 Z + \Gamma X_e + \varsigma_\tau \\ Z &= \beta_0 + \beta_1 \tau + \Psi X_Z + \varsigma_Z \end{aligned} \tag{4}$$

The vectors X_e and X_z denote the control variables, and ς_τ and ς_Z denote the error terms. Building on the parsimonious specification derived by Grossman and Helpman (1995), we estimate the importing countries' demand elasticity for crude oil, i.e., $\alpha_0 = 1/\varepsilon^*$. Moreover, because we assume the oil industry is politically connected, we expect to obtain $\alpha_1 > 0$. Returning to Eq. (2), $\alpha_1 = 1/(a \cdot \tilde{\varepsilon})$, where $\tilde{\varepsilon}$ is assumed to be constant, and $\lim_{a\to\infty} \alpha_1 = 0$; the Optimal Export Tax model is a special case of the empirical model that follows the Rich Oilmen model. As for the export intensity equation, we expect to see that $\beta_1 > 0$.

Similarly, we develop the empirical model used to evaluate the Cheap-Oil model:

$$\begin{aligned} \tau &= \theta_0 + \theta_1 \chi + \Phi X_e + \xi_\tau \text{ and} \\ \chi &= \varphi_0 + \varphi_1 \tau + \Upsilon X_Z + \xi_Z, \end{aligned} \tag{5}$$

Unlike the Rich-Oilmen model, which uses production intensity Z to predict export tax, τ, the Cheap Oil model uses consumption intensity,χ (the ratio of oil consumption to exports). We expect that $\theta_0 < 0$. The parameter θ_1 estimates the magnitude and sign of γ. Note that $\lim_{\gamma\to 0} \theta_1 = 0$; similar to the Rich-Oilmen model, the Optimal Export Tax model is embedded in the empirical model used to assess the Cheap-Oil model.

To control for the oil sector's economic strength, we include the ratios of the oil industry's revenue to real GDP. These variables are a function of crude oil prices, and therefore are also endogenous to our model. We instrument for these variables. In addition, we use a dummy variable for the years 2000 to 2006 as well as a measure of openness (see data appendix). The literature on endogenous protection suggests that the control variables should also include firm concentration, labor intensity, and geographical concentration (Gawande and Bandyopadhyay 2000; Goldberg and Maggi 1999; Trefler 1993; among many others). Unfortunately, we could not find this data for OPEC countries.

We also could not find data on domestic prices of crude oil in OPEC countries, or on gasoline consumption in OPEC countries (prices, in contrast to quantities, were obtained from Metschies et

[12] A variable addition test, devised by Wu (1973), was used to test whether the regressor Z is correlated with the disturbances (see also Green 2008, Chapter 12.4). The test rejected the hypothesis that Z is exogenous.

al. 2007). To proxy for these variables, we assume the ratio of gasoline to crude oil consumption is constant and similar among OPEC countries. An alternative approach, not taken in this paper, would be to try to estimate gasoline consumption using available data (car ownership, average miles per gallon, and annual miles per car). We believe that estimating gasoline consumption based on such assumptions would introduce more noise than is introduced by the approach chosen, which allows us to use data on crude oil production and consumption, while focusing on super gasoline and diesel prices.

To consistently estimate the structural coefficients, we first estimated the reduced form for the three endogenous variables (export tax, export intensity, revenue to GDP), using as instruments the purchasing power parity, the exchange rate, the growth rate of GDP, the proven reserves, the exogenous variables of the structural model, their quadratic terms, and their cross product taken two at a time.[13] An instrument should not be correlated with the residual, i.e., with the unsystematic component of the dependant variable. Hence, the instruments were regressed on the residuals, and the hypothesis that the coefficients equal zero was tested. We could not reject the null hypothesis for any regression. We also introduced a third equation, which estimated the sector's economic strength, to the structural model and improved the efficiency of the estimated parameters. The equation's dependent variable is revenue to real GDP, whereas the independent variables are the exogenous variables used during the first stage.

The analysis thus far assumed export taxes are identical among OPEC countries. In practice, however, the gap between international and domestic prices does vary across OPEC countries (see Table 4). To incorporate these differences, we grouped OPEC countries using the following criterion: core OPEC countries, i.e., the founders of OPEC, versus countries that joined OPEC after 1960. Specifically, we used dummy variables to allow for differences in α_1 (or θ_1), where the Rich-Oilmen model predicts $\alpha_1 > 0$ for all countries and specifications.[14] With respect to core OPEC countries, we suspect that α_1 (or θ_1) will be different between the two categories, because core OPEC countries are politically more aware of the benefits from monopolizing oil extraction and production.

[13] Kelejian (1971) showed that endogenous variables could consistently be estimated using similar techniques. See also Gawande and Bandyopadhyay (2000). Note that the order condition for identification (the number of exogenous variables excluded from each equation) is met, as is the rank condition (the rank of the submatrix of the reduced form coefficient). See also Green 2008, Chapter 13 page 368.

[14] We also distinguished among OPEC countries using proven reserves, but could not statistically support the hypothesis that the political influence of the oil sector varies between countries. Therefore, and to preserve space, we omitted this analysis from the paper. Note that higher reserves imply lower user costs. If OPEC countries are not myopic, we should expect countries with larger reserves to consume more oil in the current period and set a larger wedge. This is not what we observe. To this end, if we order the wedge set by OPEC countries from the largest to the smallest wedge (see Table 4), the wedge set by Saudi Arabia will be in seventh place, although Saudi Arabia has the largest amount of reserves by far (see Table 2). Venezuela, on the other hand, has the second largest wedge, although its proven reserves are only 80 billion barrels (see Table 2). To this end, Hamilton (2008) argued that although scarcity rents made a negligible contribution to the price of oil in 1997, it may have been an important feature of the price fluctuations during 2007/08. We also distinguished among OPEC countries using GDP per capita, which might split OPEC countries into different groups since the demand for gasoline increases with GDP per capita; car ownership increases with GDP per capita at an increasing rate (Chamon et al. 2008). We would therefore expect $\alpha_1 > 0$ (or θ_1) to be smaller for countries with higher GDP per capita. Using GDP per capita to distinguish among OPEC countries, however, does not support the hypothesis that countries with a higher GDP per capita place more weight on aggregate welfare, relative to other OPEC countries.

The empirical models were estimated using data collected by British Petroleum on production, consumption, and reserves of crude oil (see http://www.bp.com), together with data collected by the Metschies et al. (2007) on super gasoline and diesel fuel prices at the pump. Data on trade variables were taken from the IMF Statistical Databases, whereas data on real GDP and openness indices were taken from the United Nations Common Database and Penn World Table, respectively.

4.2 The empirical results

Initially, we empirically evaluated whether the behavior of OPEC as a whole supports the Rich-Oilmen or the Optimal Export Tax model, and whether OPEC behaves as a single entity. The data does not support the Rich-Oilmen model nor the hypothesis that OPEC behaves as a single entity. This conclusion led us to the Cheap-Oil model, which we evaluated empirically for OPEC as a whole, as well as for distinct countries. The Cheap-Oil model, unlike the Rich-Oilmen model, fits the data well.

We began the empirical analysis by estimating the empirical model, which builds on the Rich-Oilmen model, i.e., Eq. (4). Tables (1a) and (1b) present our results, depicting the parameters of the trade tax and export intensity equations, respectively. In our baseline specification, i.e., specification I, $\alpha_0 < 0$, $\alpha_1 > 0$ and $\beta_1 > 0$, and the parameters are significantly different from zero at a 10 percent level. The oil-importing countries' elasticity of demand, ε^*, is less than -1, i.e., $0 > \alpha_0 = 1/\varepsilon^* > -1$. These findings are consistent with those of Alhajji and Huettner (2000b), who demonstrated, using quarterly data, that although the elasticity of demand for OPEC's oil between 1973 and 1994 was less than one in absolute value, it fluctuated between -1.58 and -6.13 for Saudi Arabia.[15] Other control variables used in the analysis include the ratio of revenue from oil extraction to the volumes of imports or exports. We also used different instruments, including total trade as a percentage of GDP (OPENC) and the ratio of GNP to GDP (CGNP) in contrast to PPP. The use of different control variables and different instruments had no significant effect on the results.

Next, using the Rich-Oilmen model and the trade tax equation (Eq. 4), we computed the average political influence of oil industries in OPEC countries; i.e.,

$$a = \frac{1}{\tilde{\varepsilon} \cdot \alpha_1}. \tag{6}$$

Estimating the empirical model presented in Eq. (4) suggests that the trade policy of OPEC countries mimics the policy predicted by the Optimal Export Tax model, i.e., $\tau^{po} \cong \tau^{o}$. Under plausible assumptions on $\tilde{\varepsilon}$, the weight placed on the oil industry in OPEC countries is small (a is large). If, for example, $\tilde{\varepsilon}$ equals 0.5, then the extra weight placed on the oil sector's well-being equals 0.1% of the weight placed on aggregate welfare (i.e., $a = 1000$).

[15] See also Hamilton (2008).

Next, we extended the empirical analysis to account for differences among OPEC countries. Although multicolinearity prevents us from estimating a model that allows for differences in both the constant term and the export intensity parameter, introducing differences in only one of the parameters does support the hypothesis that OPEC is not a single entity. To this end, the data supports the hypothesis that in non-core OPEC countries, the oil sector has more political clout (note that most of OPEC reserves are located in core OPEC countries) – see Specification II, Table 1. Let subscript C denote core OPEC countries. If core and non-core OPEC countries differ only in the weight placed on consumers, i.e., a, then we can conclude that core OPEC countries place more weight on consumer well-being and $a_C < 0$. The domestic price of gasoline in core OPEC countries is lower than predicted by the Optimal Export Tax model, and the wedge is greater. Formally, let us assume $\tilde{\varepsilon}$ is constant across countries and

$$\alpha_{1,C} = \frac{1}{a_C}\frac{1}{\tilde{\varepsilon}} = \left(\frac{1}{a} + \Delta\right)\frac{1}{\tilde{\varepsilon}} \Rightarrow \frac{1}{a_C} = \left(\frac{1}{a} + \Delta\right) \Rightarrow \frac{1}{a_C} - \frac{1}{a} = \frac{a - a_C}{a \cdot a_C} = \Delta,$$

where $\alpha_{1,C}$ denotes the α_1 parameter in Eq. (4) for core OPEC countries. Then, the empirical analysis presented above suggests that $\Delta/\tilde{\varepsilon} = \alpha_{1,C} - \alpha_1 = -0.2286 < 0$, $\alpha_{1,C} < 0$ and therefore $a_C < 0$, in contrast to the Rich-Oilmen's predictions. Unlike empirical studies on developed countries, the Rich-Oilmen model does not fit the political process leading to trade policy in OPEC countries.

The results so far suggest that OPEC countries, although not symmetric, place greater weight on aggregate welfare, i.e., OPEC's pricing behavior can be approximated using the Optimal Export Tax model. However, the sign of α_1 is negative under some specifications. Under Specifications II and III, it becomes negative for a subgroup of countries, suggesting less weight to the oil sector as opposed to the rest of the economy. These empirical results contradict the Rich-Oilmen model. We, therefore, repeated the empirical analysis using the empirical model that builds on the Cheap-Oil model (Eq. (5), instead of Eq. (4)).

We estimated the Cheap-Oil model, accounting for differences among OPEC countries and assuming a structural break in 2000 (we also estimated other specifications, but the conclusions reached from comparing the two political economy models did not change). The estimated parameters are depicted in Table 3a (tax equation) and in Table 3b (consumption intensity equation). The elasticity of the residual demand for oil-importing countries is similar to that in the Rich-Oilmen model (Table 1a), and the analysis suggests it decreased after 2000 by more than 80 percent. The empirical analysis also predicts that OPEC countries as a whole, although placing more weight on consumers (the parameter is significant at a 10 percent level), set their wedge close to the wedge set by politicians who maximize aggregate welfare; the export intensity parameter in Specification I, Table 3a, equals 0.0021. In Table 4 we depict the average wedges for OPEC countries. The wedge in Venezuela, for instance, is 0.828, whereas the average wedge for OPEC countries is 0.535, i.e. 55 percent larger (0.828/0.535 – 1 = 0.55). Furthermore, the average wedge in core OPEC countries is -0.74, whereas the average wedge in non-core OPEC countries is -0.42.

Unfortunately, because the ratio of production to volume of trade is highly correlated with the ratio of consumption to volume of trade, we could not build a statistical model that would compare the two alternative specifications. The Cheap-Oil model accounting for differences between core and non-core OPEC countries, however, performs marginally better; R^2 is slightly larger. The alternative empirical model, i.e., Eq. (5), also fits the theory better; the signs of the parameters do not contradict the theory's predictions.

Before concluding, we briefly discuss the empirical results obtained if, instead of introducing heterogeneity with respect to domestic politics, we introduce heterogeneity with respect to the elasticity of the demand for oil imports. To this end, introducing a dummy variable for OPEC countries to the Rich-Oilmen model suggested that core OPEC countries (i.e., Iran, Iraq, Kuwait, Saudi Arabia and Venezuela) face lower residual demand elasticity (see Table 5). The elasticity of the residual demand dropped from -6.12 to -2.46 for core OPEC countries (specification I, Table 5). Similar results were estimated for the Cheap-Oil model, where core-OPEC countries faced lower residual demand elasticity; the elasticity dropped from -5.99 to -2.41.

To summarize: OPEC countries exploit their monopoly power in international oil markets and implicitly apply an export tax, factoring in political considerations as well as economic ones. Although the analysis suggests that the Optimal Trade Tax model explains well the average behavior of OPEC countries, OPEC should not be looked upon as a single entity; different members behave differently. Specifically, politicians in OPEC countries, especially in core OPEC countries and countries with high GDP per capita, place higher weight on the citizen's well-being.

When making policy decisions, policy makers consider consumer surplus and revenues collected from trade, in addition to profits from oil extraction. Therefore, and unlike the cartel pricing behavior, domestic consumption matters; it affects OPEC's pricing behavior. These considerations are overlooked when cartel behavior is considered, and the bias introduced becomes more significant as GDP per capita in oil-rich countries increases (e.g., car ownership increases exponentially with GDP per capita once countries pass the 5,000 USD mark). Although consumption of crude oil in the Middle East, Algeria and Venezuela together currently amounts to 10 percent of total world consumption of crude oil, consumption grew from 2005 to 2006 by 3.5%, 3.4%, and 4.3%, respectively. Consumption in the Middle East, Algeria and Venezuela grew much faster than it did in the rest of the world, where crude oil consumption grew by an insignificant 0.7%.

5 So, is OPEC a cartel?

The economic literature defines a cartel as a group of profit-maximizing firms that coordinate production decisions to maximize joint profits and collectively have large market shares. To this end, OPEC does possess market power. According to the Energy Information Administration (2007), OPEC produced 41 percent of world liquid supply (i.e., crude oil and liquefied natural gas) in 2004, whereby under plausible assumptions, 65 percent of the total increase in crude oil supply will, in future years, come from OPEC. A similar picture is revealed if, instead of production, we use proven reserves. More than 900 billion barrels of crude oil, out of a total of 1317.4 billion barrels, are located in OPEC countries (Energy Information Administration, 2007).

That said, the analysis presented in this paper illustrates how, on average, the Optimal Export Tax model describes OPEC's pricing behavior. A closer look at different countries does, however, suggest that political economic considerations lead to only small deviations from the Optimal Export Tax predictions, deviations that vary across countries. The Cheap-Oil model applies to core OPEC countries, and suggests giving extra weight to consumer welfare. The results derived in this paper also suggest that different political economic considerations guide politicians in developing countries, as opposed contrast to developed countries, when setting an export tax, as opposed to a tariff.

OPEC is not an "economic" cartel, but can be viewed as a "political" cartel among big oil-exporting countries; countries that, on average, set trade policy to maximize aggregate welfare. OPEC's evolution and durability can thus be explained by understanding the interests of countries, not firms.

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Data Appendix:

Data for energy prices paper:

1. Energy Information Administration (table posted January 14, 2008):
   (a) Reserves: Crude oil – Billion Barrels
2. International Energy Annual 2007 (Table 3.6 World Crude Oil Refining Capacity, January 1, 2006):
   (a) Oil refining capacity: Thousand Barrels per Calendar Day.
3. Prices: International Fuel Prices 2007, 5^{th} edition
4. British Petroleum publication:
   (a) Production and consumption:
      i. Production includes crude oil, shale oil, oil sands and NGLs (the liquid content of natural gas where this is recovered separately).
      ii. Consumption includes inland demand plus international aviation and marine bunkers and refinery fuel and loss. Consumption of fuel ethanol and biodiesel is also included.
      iii. Thousand barrels daily
5. Differences between world consumption and world production statistics are accounted for by stock changes, consumption of non-petroleum additives and substitute fuels, as well as unavoidable disparities in the definition, measurement or conversion of oil supply and demand data. IMF Statistical Databases variables:
   (a) Export and imports, for OPEC countries and for the rest of the world, are expressed in US dollars.
6. PENN 6.1 control variables
   (a) CGNP: From the World Bank and UN data archives the percentage of GNP to GDP has been provided. This percentage can be interpreted as national prices. CGNP can also be treated as though it were in international prices (the position expressed by the authors of the Penn World Table documentations).
   (b) OPENC: Exports plus Imports divided by GDP is the total trade as a percentage of GDP. The export and import figures are in national currencies from the World Bank and United Nations data archives. Note that when the export and import figures and GDP are expressed in real values, the value of OPENC will be the same because the price level (conversion factor), as well as exports and imports are the same.

(c) OPENK: Exports plus Imports divided by RGDPL. This is the constant price equivalent of the OPENC variable and is the total trade as a percentage of GDP. RGDPL is obtained by adding up consumption, investment, government and exports, and subtracting imports in any given year. It is a fixed base index.

(d) XRAT: IMF annual rate.

(e) PPP: Purchasing power parity is the number of currency units required to buy goods equivalent to what can be bought with one unit of the base country. It is calculated as PPP over GDP. That is, PPP is the national currency value of GDP divided by the real value of GDP in international dollars. International dollar has the same purchasing power over total U.S. GDP as the U.S. dollar in a given base year.

Tables

In the following tables * denotes a 10 percent significance level, ** denotes a 5 percent significance level, and *** denotes a 1 percent significance level. & denotes a t-statistic greater than 1.

Variables \ Specifications	(I) OPEC as a whole	(II) Core OPEC
$1/\varepsilon^*$ (i.e., α_0)	-0.1962* (0.1111)	-0.1765** (0.0814)
Export intensity (i.e., α_1)	0.0021*** (0.0005)	0.0010** (0.0004)
$\frac{\text{Revenue from oil production}}{\text{Real GDP}}$	-0.0272** (0.0120)	-0.0110& (0.010291)
The dummy equals 1 if the year is greater or equal 2000	-0.2288* (0.1199)	-0.1933** (0.088519)
Core OPEC countries		-0.2276*** (0.08287)
System Weighted R^2	0.7406	0.9808

Table 1a: The Rich-Oilmen model's trade tax equation (differences in domestic politics)

Variables \ Specifications	**(I) OPEC as a whole**	**(II) Core OPEC**
Intercept (i.e., β_0)	70.28 (54.42)	50.03 (56.57)
Tax ratio (i.e., β_1)	360.75*** (83.29)	304.86** (127.75)
$\dfrac{\text{Revenue from oil production}}{\text{Real GDP}}$	11.22* (5.692)	8.838$^{\&}$ (5.937)
The dummy variable equals 1 if the year is greater or equal 2000	75.72 (53.21)	77.36$^{\&}$ (53.03)
Core OPEC countries dummy variable		20.78 (69.35)

Table 1b: The Rich-Oilmen's export intensity equation (differences in domestic politics)

OPEC member state	Oil reserve
Saudi Arabia	262.3
Iran	136.3
Iraq	115.0
Kuwait	101.5
United Arab Emirates	97.8
Venezuela	80.0
Libya	41.5
Nigeria	36.2
Qatar	15.2
Algeria	12.3
Angola	8.0
Indonesia	<7.0

Table 2: World oil reserves by country as of January 1, 2007 (billion barrels)

Variables \ Specifications	**(I) Base Model**	**(II) Core OPEC**
$-1/\varepsilon^{*}$ **(i.e., θ_0)**	-0.1941* (0.1111)	-0.2177** (0.0909)
Consumption intensity (i.e., θ_1)	0.0021*** (0.0005)	0.0015*** (0.0005)
$\frac{\text{Revenue from oil production}}{\text{Real GDP}}$	-0.0272** (0.0120)	-0.0179$^{\&}$ (0.0109)
The dummy variable equals 1 if the year is greater or equal 2000	-0.2288* (0.1199)	--0.1916* (0.0993)
Core OPEC countries		-0.5323* (0.2848)
System Weighted R^2	0.7406	0.9896

Table 3a: The Cheap-Oil model’s trade tax equation

Variables \ Specifications	**(I) Base Model**	**(II) Core OPEC**
Intercept (i.e., ϕ_0)	69.28$^{\&}$ (54.42)	56.50$^{\&}$ (55.73)
Tax ratio (i.e., ϕ_1)	360.75*** (83.29)	297.51** (119.35)
$\frac{\text{Revenue from oil production}}{\text{Real GDP}}$	11.22* (5.692)	10.60* (5.823)
The dummy variable equals 1 if the year is greater or equal 2000	75.72$^{\&}$ (53.21)	73.14$^{\&}$ (52.61)
Dummy variable: Core OPEC countries		-23.13 (61.00)

Table 3b: The Cheap-Oil model’s export intensity equation

Country	Wedge
Iraq	-0.95
Venezuela	-0.83
Iran	-0.83
Libya	-0.63
Qatar	-0.6
Kuwait	-0.55
Saudi Arabia	-0.54
Nigeria	-0.51
UAE	-0.38
Algeria	-0.29
Indonesia	-0.29
Angola	-0.24

Table 4: The predicted wedge

Variables \ Specifications	**(I) Core OPEC**
$-1/\varepsilon^*$ (i.e., α_0)	-0.16331* (0.087712)
Export intensity (i.e., α_1)	0.001156** (0.000488)
$\frac{\text{Revenue from oil production}}{\text{Real GDP}}$	-0.01377& (0.010676)
The dummy variable equals 1 if the year is greater or equal 2000	-0.21300** (0.093763)
Dummy variable: Core OPEC countries	-0.24400** (0.105848)
System Weighted R^2	0.9811

Table 5a: The Rich-Oilmen model's trade tax equation (differences in import demand elasticity)

Variables \ Specifications	**(I) Core OPEC**
$-1/\varepsilon^{*}$ (i.e., θ_0)	-0.16706* (0.087744)
Consumption intensity $\left(i.e.,\ \theta_1\right)$	0.001136** (0.000488)
$\frac{\text{Revenue from oil production}}{\text{Real GDP}}$	-0.01420& (0.010678)
The dummy variable equals 1 if the year is greater or equal 2000	-0.19498** (0.094115)
Dummy variable: Core OPEC countries	-0.24720** (0.105853)
System Weighted R^2	0.9896

Table 5b: The Cheap-Oil model's trade tax equation (differences in import demand elasticity)