A Structural Econometric Model of the Dynamic Game Between Petroleum Producers in the World Petroleum Market*

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Abstract

In this paper, we develop and estimate a structural econometric model of the dynamic game among petroleum-producing firms in the world petroleum market. Our model allows firms that are at least partially state-owned to have objectives other than profit maximization alone. We use the structural econometric model to analyze the effects of changes in OPEC membership, the privatization of state-owned oil companies, a ban on mergers, and demand shocks on the petroleum industry. Our modeling outcomes can be used to help inform decision-making and policy design. The results of our research will be of interest to academics, policy-makers, entrepreneurs, and business practitioners, including oil companies, alike. This model will also help petroleum firms better respond to government policies, and will help policy-makers better design sustainable energy policies.

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1 Introduction

Fossil fuels supply more than 80 percent of the energy consumed in the world (U.S. Energy Information Administration, 2013). Oil and natural gas provide a large share of energy consumption and getting access to secure sources of oil and natural gas is of huge importance for any economy. The production and consumption of oil and natural gas raise concerns about climate change, fossil fuel price volatility, energy security, and possible fossil fuel scarcity.

In this paper, we develop and estimate a structural econometric model of the dynamic game among petroleum-producing firms in the world petroleum market. Our model allows firms that are at least partially state-owned to have objectives other than profit maximization alone. We apply this model to panel data on firm-level oil and gas exploration, development, production, mergers, acquisitions, and reserves along with data on oil and gas prices to study the behavior of the top 50 oil and natural gas producing companies.

We use the structural econometric model to analyze the effects of changes in OPEC policy, the privatization of state-owned oil companies, production quotas, a ban on mergers, and demand shocks on the petroleum industry.

There are several advantages to using a dynamic structural model to analyze the investment, production, merger, and acquisition decisions of petroleum-producing firms. First, unlike reduced-form models, a structural approach explicitly models the dynamics of these decisions. The production decisions of oil and gas producers are dynamic because petroleum is a nonrenewable resource; as a consequence, current extraction and production affect the availability of reserves for future extraction and production. The exploration, development, merger, and acquisition decisions of petroleum producers are dynamic because they are irreversible investments, because their payoffs are uncertain, and because petroleum producers have leeway over the timing of these investment decisions. Since the profits from these investment and production decisions depend on market conditions such as the oil price that

vary stochastically over time, an individual firm operating in isolation that hopes to make dynamically optimal decisions would need to account for the option value to waiting before making these irreversible investments (Dixit and Pindyck, 1994).

Second, our model of the dynamic game between petroleum producers models the strategic nature of the decisions of petroleum-producing firms. Petroleum producers consider not only future market conditions but also their competitors' investment and production activities when making their current decisions. Since the production decisions of other firms affect the prices of oil and natural gas, and therefore affect a firm's current payoff from production, and since the investment and production decisions of other firms affect future values of state variables which affect a firm's future payoff from producing and investing, petroleum-producing firms must anticipate the production and investment strategies of other firms in order to make a dynamically optimal decision. As a consequence, there are strategic interactions between petroleum-producing firms. In addition, the uncertainty over the production and investment strategies of other firms is another reason there is an option value to waiting before investing (Dixit and Pindyck, 1994).

A third advantage of our structural model is that it enables us to estimate the effect of each state variable on the expected payoffs from exploration, development, production, merger, and acquisition decisions, and therefore enables us to estimate parameters that have direct economic interpretations. Our dynamic model accounts for the continuation value, which is the expected value of the value function next period. With the structural model we are able to estimate parameters in the payoffs from exploration, development, production, merger, and acquisition, since we are able to structurally model how the continuation values relate to the payoffs from each of these decisions.

A fourth advantage of our structural model is that we are able to model the interdependence of petroleum-producing firms' value functions. When one firm merges with or acquires another firm, the value of the other firm it merges with or acquires is given by that

other firm's value function, which is the present discounted value of the entire stream of per-period payoffs of that other firm, and which accounts for the options that that other firm has to explore, develop, produce, merge, and/or acquire. Thus, a firm's value function depends on the expected value of other firms it has the option to merge with or acquire. As a consequence, the firms' value functions are interdependent.

A fifth advantage of our structural model is that we can use the parameter estimates from our structural model to simulate various counterfactual scenarios. We use our estimates to simulate several counterfactual scenarios to analyze the effects of changes in OPEC membership, the privatization of state-owned oil companies, a ban on mergers, and demand shocks on the petroleum industry.

The results of our research will be of interest to academics, policy-makers, entrepreneurs, and business practitioners, including oil companies, alike. Our modeling outcomes can be used to help inform decision-making and policy design. This model will also help petroleum firms better respond to government policies, and will help policy-makers better design sustainable energy policies.

2 Literature Review

2.1 Models of the world petroleum market

We build on the empirical literature on the world petroleum market, much of which is from over three decades ago (Adelman, 1962; Kennedy, 1974; Nordhaus, 1980; Gately, 1984; Griffin, 1985; Lin Lawell, 2011; Espinasa et al., 2017). Cremer and Salehi-Isfahani (1991) provide a survey of models of the oil market. Many previous empirical studies of world petroleum market use a static model; one exception is Lin Lawell (2017). Unlike many previous empirical studies of the petroleum market, which use a static model, we estimate a dynamic model of the world petroleum market.

We also build on the empirical literature analyzing strategic behavior in the world petroleum market, and particularly the behavior of OPEC (Griffin, 1985; Matutes, 1988; Golombek et al., 2014; Gulen, 1996; Farzin, 1985; Alhajji and Huettner, 2000a,b; Kaufmann et al., 2004; Almoguera et al., 2011; Hochman and Zilberman, 2015). For a detailed review of the literature on oil market modeling and OPEC's behavior, see Al-Qahtani et al. (2008).

Our dynamic model of oil production builds on the theoretical model of optimal nonrenewable resource extraction that was first examined by Hotelling (1931), and then expanded upon by many others (see e.g., Solow and Wan (1976); Hanson (1980); Pesaran (1990); Pindyck (1978, 1980); Farzin (1992, 1995); Young and Ryan (1996); Zhang and Lin Lawell (2017); Lin and Wagner (2007); Lin (2009b); Lin et al. (2009); Gao et al. (2009); Leighty and Lin (2012); Almansour and Insley (2016); Zhang and Lin Lawell (2017); Ghandi and Lin Lawell (2017); Anderson et al. (2017)).

2.2 Models of mixed oligopoly and state-owned firms

The second strand of literature we build upon is that on mixed oligopoly and state-owned firms. A mixed oligopoly is defined as an oligopolistic market structure with a relatively small number of firms for which the objective of at least one firm differs from that of other firms (de Fraja and Delbono, 1990), as opposed to a private oligopoly in which all firms have the objective of profit maximization. Usually in a mixed oligopoly there is a public firm competing with a multitude of profit-maximizing firms (Poyago-Theotoky, 2001). A market where there are both private and public firms is then a mixed oligopoly because the firms owned by private agents aim to maximize profits, whereas the publicly owned firms are interested in optimizing social targets (de Fraja and Delbono, 1990).

de Fraja and Delbono (1989) study a situation in which private and public firms compete both using only market instruments. When talking about public and private firms, they think of firms which pursue different objectives. They find that nationalization is always so-

cially better than Stackelberg leadership, which is in turn socially better than Cournot-Nash behavior. If there is no way of avoiding competition with a public firm, private entrepreneurs would prefer the public firm to behave as a Stackelberg leader.

Fjell and Pal (1996) consider a mixed oligopoly model in which a state-owned public firm competes with both domestic and foreign private firms. White (1996) examines the use of output subsidies in the presence of a mixed oligopoly. Poyago-Theotoky (2001) show that the optimal output subsidy is identical and profits, output and social welfare are also identical irrespective of whether (i) the public firm moves simultaneously with the private firms or (ii) the public firm acts as Stackelberg leader or (iii) all firms behave as profit-maximizers. de Fraja and Valbonesi (2009) make the point that behavior which would be deemed anti-competitive for a profit maximizing oligopolist may be in line with the objective function of a public, welfare-maximizing supplier. Lutz and Pezzino (2010) find that mixed competition is always socially desirable compared to a private duopoly regardless of the type of competition in the short run and the equilibrium quality ranking. Bennett and La Manna (2012) find that whenever a mixed oligopoly is viable, then aggregate output, aggregate costs and welfare are the same with and without the public firm. Haraguchi and Matsumura (2016) revisit the classic discussion comparing price and quantity competition, but in a mixed oligopoly in which one state-owned public firm competes against private firms.

A related literature is that on the objectives of state-owned firms. Ghandi and Lin (2012) model the dynamically optimal oil production on Irans offshore Soroosh and Nowrooz fields, which have been developed by Shell Exploration through a buy-back service contract. In particular, they examine the National Iranian Oil Companys (NIOC) actual and contractual oil production behavior and compare it to the production profile that would have been optimal under the conditions of the contract. They find that the contracts production profile is different from optimal production profile for most discount rates, and that the NIOCs actual behavior is inefficient- its production rates have not maximized profits. Because the

NIOCs objective is purported to be maximizing cumulative production instead of the present discounted value of the entire stream of profits, they also compare the NIOCs behavior to the production profile that would maximize cumulative production. They find that even though what the contract dictates comes close to maximizing cumulative production, the NIOC has not been achieving its own objective of maximizing cumulative production.

2.3 Dynamic structural econometric models

Structural econometric models of dynamic behavior have been applied to bus engine replacement (Rust, 1987), nuclear power plant shutdown decisions (Rothwell and Rust, 1997), water management (Timmins, 2002), air conditioner purchase behavior Rapson (2014), wind turbine shutdowns and upgrades (Cook and Lin Lawell, 2017), fisheries (Huang and Smith, 2014), copper mining decisions (Aguirregabiria and Luengo, 2016) long-term and short-term decision-making for disease control (Carroll et al., 2017b); supply chain externalities (Carroll et al., 2017c); agricultural productivity (Carroll et al., 2017a); and the spraying of pesticides (Sambucci et al., 2017).

Structural econometric models of dynamic games include the model developed by Pakes, Ostrovsky, and Berry (2007), which has been applied to the multi-stage investment timing game in offshore petroleum production (Lin, 2013), to ethanol investment decisions (Thome and Lin Lawell, 2017), and to the decision to wear and use glasses (Ma et al., 2017); and the model developed by Bajari et al. (2015), which has been applied to ethanol investment (Yi and Lin Lawell, 2017b,a).

Lin (2013) develops and estimates a structural model of the multi-stage investment timing game in offshore petroleum production. When individual petroleum-producing firms make their exploration and development investment timing decisions, positive information externalities and negative extraction externalities may lead them to interact strategically with their neighbors. If they do occur, strategic interactions in petroleum production would

lead to a loss in both firm profit and government royalty revenue. The possibility of strategic interactions thus poses a concern to policy-makers and affects the optimal government policy. Lin (2013) examines whether these inefficient strategic interactions take place on U.S. federal lands in the Gulf of Mexico. In particular, she analyzes whether a firm's production decisions and profits depend on the decisions of firms owning neighboring tracts of land. The empirical approach is to estimate a structural econometric model of the firms' multi-stage investment timing game. Lin (2009a) uses a reduced-form model to examine whether strategic interactions take place during petroleum exploration.

Thome and Lin Lawell (2017) examine how economic factors, government policy, and strategic interactions affect decisions about when and where to invest in building new ethanol plants. They model the decision to invest in ethanol plants using both reduced-form discrete response models and a structural model of a dynamic game. Yi and Lin Lawell (2017b,a) estimate a model of the investment timing game in ethanol plants worldwide that allows for the choice among different feedstocks.

In this paper, we apply the structural econometric model of a dynamic game that was developed by Bajari, Benkard, and Levin (2007). This model has been applied to the cement industry (Ryan, 2012; Fowlie et al., 2016); to the production decisions of ethanol producers (Yi et al., 2017), and to migration decisions (Rojas Valdes et al., 2017b,a).

Yi, Lin Lawell, and Thome (2017) use a structural econometric model of a dynamic game to analyze the effect of government subsidies and the Renewable Fuel Standard (RFS) on the US ethanol industry. Analyses that ignore the dynamic implications of these policies, including their effects on incumbent ethanol firms' investment, production, and exit decisions and on potential entrants' entry behavior, may generate incomplete estimates of the impact of the policies and misleading predictions of the future evolution of the fuel ethanol industry. Yi, Lin Lawell, and Thome (2017) construct a dynamic model to recover the entire cost structure of the industry including the distributions of fixed entry costs and of exit scrap

values. They use the estimated parameters to evaluate three different types of subsidy: a volumetric production subsidy, an investment subsidy, and an entry subsidy, each with and without the RFS. Results show that the RFS is a critically important policy for supporting the sustainability of corn-based fuel ethanol production, and that investment subsidies and entry subsidies are more effective than production subsidies.

Ryan (2012) uses a structural econometric model to measure the welfare costs of the 1990 Clean Air Act Amendments on the US Portland cement industry. Unlike typical static cost analyses, which ignore the sunk costs of entry and investment, Ryan (2012) explicitly accounts for the dynamic effects resulting from a change in the cost structure resulting from the regulation. His results show that the Clean Air Act Amendments increased the sunk costs of entry, which negatively affected potential entrants and partially benefited incumbents because of lower ex post competition. Fowlie et al. (2016) build on this structural econometric model to analyze market-based emissions regulation.

3 Methodology

In this paper we use a structural econometric model developed by Bajari, Benkard, and Levin (2007), which was applied by Ryan (2012) and Fowlie et al. (2016) to examine the effects of environmental regulation on the cement industry and by Yi, Lin Lawell, and Thome (2017) to examine the effect of government subsidies and the Renewable Fuel Standard (RFS) on the US ethanol industry.

We model the dynamic game among the top 50 petroleum producers in the world. Each period, each petroleum producer decides how much oil and natural gas to produce; how much to spend on each type of capital expenditure (exploration, development, and acquisition [1]); whether to acquire another firm or be acquired by another firm; and whether to merge with

[1] Acquisition capital expenditures include acquiring machinery and any other type of asset.

another firm. The actions a_i of each firm i are assumed to be functions of a set of state variables and private information:

$$a_i = \sigma_i(s, \varepsilon_i) \tag{1}$$

where s is a vector of publicly observable state variables and ε_i is a vector of private information shocks to agent i which are not observed by either other firms or the econometrician.

We include the following firm-specific state variables: oil and natural gas reserves, cumulative oil and natural gas output; cumulative exploration, acquisition, and development expenditure; percentage of state ownership; whether the firm is a member of OPEC; whether the firm merged in the previous year; and whether the firm acquired another firm in the previous year. We include the following global state variables: average industry rate of return on capital for mining and quarry; average capital compensation on other machinery and equipment; world population; world GDP; world motor vehicles; world road sector gasoline fuel consumption; and world electricity production from oil and natural gas sources.

We model the oil market as a world market. Unlike the oil market, however, the natural gas market is not necessarily a world market. Due to the lack of a global pipeline network, the market for natural gas is mostly defined by proximity to supply sources and the availability of a pipeline. We consider 6 separate regional markets r for natural gas: Africa; Asia and Oceania; Eurasia; Europe; Middle East; and Americas.

The world demand for oil and and the regional demand for natural gas in region r are given by:

$$
\begin{aligned}
Q_{oil} &= D_{oil}(p_{oil}) \\
&= \alpha_{10} + \alpha_{11} p_{oil} + X'_{oil}\alpha_{1x} + \nu_1 \qquad (2) \\
Q_{ng_r} &= D_{ng_r}(p_{ng_r}) \\
&= \alpha_{20} + \alpha_{21} p_{ng_r} + X'_{ng_r}\alpha_{2x} + \nu_{2_r}, \qquad (3)
\end{aligned}
$$

where X_{oil} and X_{ng} are vectors of other variables; α_{1x} and α_{2x} are their corresponding vectors of coefficients; and ν_1 and ν_{2_r} are shocks to oil demand and regional natural gas demand, respectively. The prices of oil and natural gas are thus determined by the following inverse demand functions:

$$
\begin{aligned}
p_{oil} &= D^{-1}_{oil}(Q_{oil}) \\
&= -\frac{\alpha_{10}}{\alpha_{11}} + \frac{1}{\alpha_{11}} Q_{oil} - \frac{1}{\alpha_{11}} X'_{oil}\alpha_{1x} - \frac{1}{\alpha_{11}}\nu_1 \\
&= -\frac{\alpha_{10}}{\alpha_{11}} + \frac{1}{\alpha_{11}} \left(q_{i,oil} + \sum_{j \neq i} q_{j,oil} \right) - \frac{1}{\alpha_{11}} X'_{oil}\alpha_{1x} - \frac{1}{\alpha_{11}}\nu_1 \qquad (4)
\end{aligned}
$$

$$
\begin{aligned}
p_{ng_r} &= D^{-1}_{ng_r}(Q_{ng_r}) \\
&= -\frac{\alpha_{20}}{\alpha_{21}} + \frac{1}{\alpha_{21}} Q_{ng_r} - \frac{1}{\alpha_{21}} X'_{ng_r}\alpha_{2x} - \frac{1}{\alpha_{21}}\nu_{2_r} \\
&= -\frac{\alpha_{20}}{\alpha_{21}} + \frac{1}{\alpha_{21}} \left(q_{i,ng_r} + \sum_{j \neq i} q_{j,ng_r} \right) - \frac{1}{\alpha_{21}} X'_{ng_r}\alpha_{2x} - \frac{1}{\alpha_{21}}\nu_{2_r}, \qquad (5)
\end{aligned}
$$

where $q_{i,oil}$ and $q_{i,ng}$ are company i's oil and natural gas production respectively.

We assume the cost of oil and natural gas exploration and development for each company

i is given by the following quadratic functions:

$$c_{i,oil}(q_{i,oil}, z_{i,oil}; \delta_{11}, \delta_{12}, \delta_{13}, \delta_{14}) = \delta_{11} q_{i,oil} + \delta_{12} q_{i,oil}^2 + \delta_{13} z_{i,oil} + \delta_{14} q_{i,oil} \cdot z_{i,oil} \tag{6}$$

$$c_{i,ng}(q_{i,ng}, z_{i,ng}; \delta_{21}, \delta_{22}, \delta_{23}, \delta_{24}) = \delta_{21} q_{i,ng} + \delta_{22} q_{i,ng}^2 + \delta_{23} z_{i,ng} + \delta_{24} q_{i,ng} \cdot z_{i,ng}, \tag{7}$$

where δ_{11}, δ_{12}, δ_{13} , δ_{14}, δ_{21}, δ_{22}, δ_{23}, and δ_{24} are variable cost coefficients and $z_{i,oil}$ and $z_{i,ng}$ are firm i's oil and natural gas reserves respectively.

Firms can invest in capital in three forms of exploration, development, and acquisition capital expenditure. Let x_i be the total capital expenditure of firm i, which is given by:

$$x_i = x_{i,exp} + x_{i,dvp} + x_{i,acq}. \tag{8}$$

The per-period profit function from production of oil and natural gas for company i is then given by:

$$\begin{aligned}
&\bar{\pi}_i\left(s, a; \hat{\alpha}, \delta\right) \\
&= \underbrace{\left(p_{oil}(s, Q_{oil})\, q_{i,oil} - \delta_{11} q_{i,oil} - \delta_{12} q_{i,oil}^2 - \delta_{13} z_{i,oil} - \delta_{14} q_{i,oil} \cdot z_{i,oil}\right)}_{\text{Profit from production of oil}} \\
&+ \underbrace{\left(\sum_{r=1}^{6} p_{ng_r}(s, Q_{ng_r})\, q_{i,ng_r} - \delta_{21} q_{i,ng} - \delta_{22} q_{i,ng}^2 - \delta_{23} z_{i,ng} - \delta_{24} q_{i,ng} \cdot z_{i,ng}\right)}_{\text{Profit from production of natural gas}},
\end{aligned} \tag{9}$$

Firm i's payoff $\Phi_i(s, a_i)$ from mergers and/or acquisition is also defined as follows:

$$\Phi_i(s, a_i) = \begin{cases} -\Gamma_i^B + EV_j(s; \sigma, \theta) \cdot \eta_1 & \text{if firm } i \text{ acquires firm } j \\ \Gamma_i^S & \text{if firm } i \text{ is acquired by firm } j \\ -\Lambda_i + EV_j(s; \sigma, \theta) \cdot \eta_2 & \text{if firms } i \text{ and } j \text{ merge into one firm} \end{cases}$$

where Γ_i^B is the cost to firm i of acquiring other firm, Γ_i^S is the benefit to firm i of being

acquired, and Λ_i is the cost to firm i of merging.

Using the inverse demand for oil and natural gas given by equations (4) and (5), we calculate the consumer surplus from oil and natural gas consumption, respectively, as follows:

$$\begin{aligned} CS_{oil} &= \int_0^{Q_{oil}} D_{oil}^{-1}(x)dx - p_{oil}Q_{oil} \\ &= \left(\frac{-\alpha_{10} - X'_{oil}\alpha_{1x} - \nu_1}{\alpha_{11}}\right) Q_{oil} + \frac{1}{2\alpha_{11}} Q_{oil}^2 - p_{oil}Q_{oil} \end{aligned} \tag{10}$$

$$\begin{aligned} CS_{ng_r} &= \int_0^{Q_{ng_r}} D_{ng_r}^{-1}(x)dx - p_{ng_r}Q_{ng_r} \\ &= \left(\frac{-\alpha_{20} - X'_{ng_r}\alpha_{2x} - \nu_{2_r}}{\alpha_{21}}\right) Q_{ng_r} + \frac{1}{2\alpha_{21}} Q_{ng_r}^2 - p_{ng_r}Q_{ng_r} \end{aligned} \tag{11}$$

Total consumer surplus from oil and natural gas consumption is therefore given by:

$$CS = CS_{oil} + \sum_{r=1}^{6} CS_{ng_r} \tag{12}$$

World consumer surplus is not the same as the consumer surplus faced by firms that are at least partially state-owned. We define the consumer surplus for oil faced by firm i as the world consumer surplus for oil times firm is oil production as a fraction of world oil production (where world old production is total oil production over the top 50 firms).

For each natural gas region, we define consumer surplus for natural gas in that region faced by firm i as the world consumer surplus for natural gas in that region times firm is natural gas production in that region as a fraction of total natural gas production in the region (summed over the top 50 firms).

The consumer surplus CS_i faced by firm i is therefore given by the following weighted sum of the consumer surplus from oil and the consumer surplus from natural gas consumption in each region, each weighted by firm i's respective share in the total production of oil and regional natural gas:

$$CS_i = CS_{oil}\frac{q_{i,oil}}{Q_{oil}} + \sum_{r=1}^{6} CS_{ng_r}\frac{q_{i,ng_r}}{Q_{ng_r}} \tag{13}$$

We assume that private firms care solely about profit, while firms that are at least partially state-owned may put some weight on the consumer surplus faced by that firm as well.

The per-period payoff function is therefore as follows:

$$\begin{aligned}\pi_i(s,a;\hat{\alpha},\delta,\Gamma,\Lambda) =& \pi_i(s,a;\hat{\alpha},\theta) \\ =& \underbrace{\bar{\pi}_i(s,a;\hat{\alpha},\delta)}_{\text{production profit}} + \omega_1 O_{it,state} + \omega_2 O_{it,OPEC} + \underbrace{\Phi_i(s,a_i)}_{\text{M\&A}} - \underbrace{x_i}_{\text{capex}} + \\ & \rho_\pi O_{i,state}\bar{\pi}_i + \rho_{CS} O_{i,state} CS_i + \delta_0,\end{aligned} \tag{14}$$

where δ_0 is a constant, $O_{i,state}$ denotes the fraction of state ownership in firm i, and $O_{i,OPEC}$ denotes a dummy variable for whether firm i is an OPEC member. We will impose that for state-owned firms, the weights on production profit and consumer surplus add up to 1. Thus we assume that $1 + \rho_\pi O_{it,state} + \rho_{CS} O_{it,state} = 1$ which implies that $\rho_{CS} = -\rho_\pi$.

Assuming the per-period payoff is linear in parameters θ we can write:

$$\pi_i(s,a,\varepsilon_i;\hat{\alpha},\theta) = \Psi_i(s,a,\varepsilon_i;\hat{\alpha})\cdot\theta. \tag{15}$$

The expected present discounted value of the entire stream of profits for firm i is given

by the following value function $V_i(s;\sigma,\theta)$:

$$\begin{aligned} V_i(s;\sigma,\theta) =& \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t\pi_i(s,a,\varepsilon_i;\hat{\alpha},\theta)\right] \\ =& \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t\Psi_i(\sigma(s_t,\varepsilon_t),s_t,\varepsilon_{it};\hat{\alpha})\right]\cdot\theta \\ =& W_i(s;\sigma)\cdot\theta, \end{aligned} \tag{16}$$

where $W_i = [W_i^1, W_i^2, ..., W_i^{39}]$ does not depend on vector of parameters θ and which can be expanded out into its constituent terms as follows:

$$
\begin{aligned}
&V_i(s;\sigma,\theta) = \\
&\quad \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t P_{t,oil}(s_{it},Q_{t,oil})\cdot q_{it,oil}\right] - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t q_{it,oil}\right]\cdot\delta_{11} - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t q_{it,oil}^2\right]\cdot\delta_{12} - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t z_{it,oil}\right]\cdot\delta_{13} - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t z_{it,oil}\cdot q_{it,oil}\right]\cdot\delta_{14} \\
&+\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t \sum_{r=1}^{6} p_{ng_r}(s,Q_{ng_r})\, q_{i,ng_r}\right] - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t q_{it,ng}\right]\cdot\delta_{21} - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t q_{it,ng}^2\right]\cdot\delta_{22} - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t z_{it,ng}\right]\cdot\delta_{23} - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t z_{it,ng}\cdot q_{it,ng}\right]\cdot\delta_{24} \\
&+\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state}\right]\cdot\omega_1 + \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,OPEC}\right]\cdot\omega_2 \\
&-\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t p_M(s_{it})\cdot\left(\lambda_1 p_M + \lambda_2 {p_B}^2 + \lambda_3 {p_S}^2 + \lambda_4 {p_M}^2\right)\right] + \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t p_M(s_{it})\cdot EV_j(s;\sigma,\theta)\right]\cdot\eta_1 \\
&-\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t p_B(s_{it})\cdot\left(\gamma_{11} p_B + \gamma_{12} {p_B}^2 + \gamma_{13} {p_S}^2 + \gamma_{14} {p_M}^2\right)\right] + \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t p_B(s_{it})\cdot EV_j(s;\sigma,\theta)\right]\cdot\eta_2 \\
&+\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t p_S(s_{it})\cdot\left(\gamma_{21} p_S + \gamma_{22} {p_B}^2 + \gamma_{23} {p_S}^2 + \gamma_{24} {p_M}^2\right)\right] - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t x_{it}\right] + \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t\right]\delta_0 \\
&-\rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state} P_{t,oil}(s_{it},Q_{t,oil})\cdot q_{it,oil}\right] + \rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state} q_{it,oil}\right]\cdot\delta_{11} + \rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state} q_{it,oil}^2\right]\cdot\delta_{12} \\
&+\rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state} z_{it,oil}\right]\cdot\delta_{13} + \rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state} z_{it,oil}\cdot q_{it,oil}\right]\cdot\delta_{14} \\
&-\rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state}\sum_{r=1}^{6} p_{ng_r}(s,Q_{ng_r})\, q_{i,ng_r}\right] + \rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state} q_{it,ng}\right]\cdot\delta_{21} + \rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state} q_{it,ng}^2\right]\cdot\delta_{22} \\
&+\rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state} z_{it,ng}\right]\cdot\delta_{23} + \rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state} z_{it,ng}\cdot q_{it,ng}\right]\cdot\delta_{24} + \rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state} CS_{it}\right], \qquad (17)
\end{aligned}
$$

which can be rewritten as:

$$
\begin{aligned}
&V_i(s;\sigma,\theta) = \\
&\quad \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t P_{t,oil}(s_{it},Q_{t,oil})\cdot q_{it,oil}\right] - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t q_{it,oil}\right]\cdot\delta_{11} - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t q_{it,oil}^2\right]\cdot\delta_{12} - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t z_{it,oil}\right]\cdot\delta_{13} - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t z_{it,oil}\cdot q_{it,oil}\right]\cdot\delta_{14} \\
&+\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t \sum_{r=1}^{6} p_{ng_r}(s,Q_{ng_r})\, q_{i,ng_r}\right] - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t q_{it,ng}\right]\cdot\delta_{21} - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t q_{it,ng}^2\right]\cdot\delta_{22} - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t z_{it,ng}\right]\cdot\delta_{23} - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t z_{it,ng}\cdot q_{it,ng}\right]\cdot\delta_{24} \\
&+\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state}\right]\cdot\omega_1 + \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,OPEC}\right]\cdot\omega_2 \\
&-\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t (p_M(s_{it}))^2\right]\cdot\lambda_1 - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t p_M(s_{it})\cdot(p_B(s_{it}))^2\right]\cdot\lambda_2 - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t p_M(s_{it})\cdot(p_S(s_{it}))^2\right]\cdot\lambda_3 - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t (p_M(s_{it}))^3\right]\cdot\lambda_4 \\
&+\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t p_M(s_{it})\cdot EV_j(s;\sigma,\theta)\right]\cdot\eta_1 \\
&-\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t (p_B(s_{it}))^2\right]\cdot\gamma_{11} - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t (p_B(s_{it}))^3\right]\cdot\gamma_{12} - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t p_B(s_{it})\cdot(p_S(s_{it}))^2\right]\cdot\gamma_{13} - \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t p_B(s_{it})\cdot(p_M(s_{it}))^2\right]\cdot\gamma_{14} \\
&+\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t p_B(s_{it})\cdot EV_j(s;\sigma,\theta)\right]\cdot\eta_2 \\
&+\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t (p_S(s_{it}))^2\right]\cdot\gamma_{21} + \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t p_S(s_{it})\cdot(p_B(s_{it}))^2\right]\cdot\gamma_{22} + \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t (p_S(s_{it}))^3\right]\cdot\gamma_{23} + \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t p_S(s_{it})\cdot(p_M(s_{it}))^2\right]\cdot\gamma_{24} \\
&-\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t x_{it}\right] + \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t\right]\delta_0 - \rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state}P_{t,oil}(s_{it},Q_{t,oil})\cdot q_{it,oil}\right] + \rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state}q_{it,oil}\right]\cdot\delta_{11} \\
&+\rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state}q_{it,oil}^2\right]\cdot\delta_{12} + \rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state}z_{it,oil}\right]\cdot\delta_{13} + \rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state}z_{it,oil}\cdot q_{it,oil}\right]\cdot\delta_{14} \\
&-\rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state}\sum_{r=1}^{6} p_{ng_r}(s,Q_{ng_r})\, q_{i,ng_r}\right] + \rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state}q_{it,ng}\right]\cdot\delta_{21} + \rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state}q_{it,ng}^2\right]\cdot\delta_{22} \\
&+\rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state}z_{it,ng}\right]\cdot\delta_{23} + \rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state}z_{it,ng}\cdot q_{it,ng}\right]\cdot\delta_{24} + \rho_{CS}\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t O_{it,state}CS_{it}\right]. \qquad (18)
\end{aligned}
$$

This value function can be summarized as:

$$\begin{aligned}
V_i(s;\sigma,\theta) =& W_i^1 - W_i^2 \cdot \delta_{11} - W_i^3 \cdot \delta_{12} - W_i^4 \cdot \delta_{13} - W_i^5 \cdot \delta_{14} \\
&+ W_i^6 - W_i^7 \cdot \delta_{21} - W_i^8 \cdot \delta_{22} - W_i^9 \cdot \delta_{23} - W_i^{10} \cdot \delta_{24} + W_i^{11} \cdot \omega_1 + W_i^{12} \cdot \omega_2 \\
&- W_i^{13} \cdot \lambda_1 - W_i^{14} \cdot \lambda_2 - W_i^{15} \cdot \lambda_3 - W_i^{16} \cdot \lambda_4 + W_i^{17} \cdot \eta_1 \\
&- W_i^{18} \cdot \gamma_{11} - W_i^{19} \cdot \gamma_{12} - W_i^{20} \cdot \gamma_{13} - W_i^{21} \cdot \gamma_{14} + W_i^{22} \cdot \eta_2 \\
&+ W_i^{23} \cdot \gamma_{21} + W_i^{24} \cdot \gamma_{22} + W_i^{25} \cdot \gamma_{23} + W_i^{26} \cdot \gamma_{24} - W_i^{27} + W_i^{28} \cdot \delta_0 \\
&- W_i^{29} \cdot \rho_{CS} + W_i^{30} \cdot \delta_{11} \cdot \rho_{CS} + W_i^{31} \cdot \delta_{12} \cdot \rho_{CS} + W_i^{32} \cdot \delta_{13} \cdot \rho_{CS} + W_i^{33} \cdot \delta_{14} \cdot \rho_{CS} \\
&- W_i^{34} \cdot \rho_{CS} + W_i^{35} \cdot \delta_{21} \cdot \rho_{CS} + W_i^{36} \cdot \delta_{22} \cdot \rho_{CS} + W_i^{37} \cdot \delta_{23} \cdot \rho_{CS} + W_i^{38} \cdot \delta_{24} \cdot \rho_{CS} \\
&+ W_i^{39} \cdot \rho_{CS} \qquad (19)
\end{aligned}$$

where p_B, p_S, and p_M are probabilities of acquiring another firm, being acquired by another firm, and merger, respectively.

We assume that each firm optimizes its behavior conditional on the current state variables, other agents' strategies and its own private shocks, which results in a Markov perfect equilibrium (MPE). The optimal strategy $\sigma_i^*(s)$ for each player i should therefore satisfy the following condition for all state variables s and alternative strategies $\tilde{\sigma}_i(s)$:

$$V_i(s;\sigma_i^*(s),\sigma_{-i},\theta,\varepsilon_i) \geq V_i(s;\tilde{\sigma}_i(s),\sigma_{-i},\theta,\varepsilon_i). \qquad (20)$$

In our dynamic game, a firm's decisions may depend on the decisions of other firms through several channels. First, aggregate output of oil and natural gas affect the prices of oil and natural gas faced by each firm; as a consequence, owing to market power, each firm's production decisions affect the prices faced by all firms. Second, aggregate output, aggregate reserves, and aggregate capital expenditures affect each firm's policy functions. Thus, each firm's decisions depend on the aggregate output and capital expenditure decisions

of all firms, and on the aggregate reserves of all firms. Third, aggregate output affects the transition densities for the global state variables. Thus, production decisions of each firm affect future values of the state variables, which then affect the payoffs and decisions of all firms.

There are several sources of uncertainty in our model of a dynamic game. First, future values of the state variables are stochastic. Second, each player i receives private information shocks ε_i. Third, there are shocks to oil demand and regional natural gas demand. Fourth, merger and acquisition costs are private information to each firm i, and are not observed by either other firms or the econometrician.

The parameters θ to be estimated include the production profit parameters δ, the merger fixed cost parameters λ, the acquisition fixed cost parameters γ_1 and the selling value parameters γ_2.

We estimate the structural econometric model in two steps. In the first step, we characterize the equilibrium policy functions for the firms' decisions regarding exploration, development, production, merger, and acquisition as functions of state variables by using reduced-form regressions correlating actions to states. We also estimate the transition density for the state variables. We then calculate value functions using forward simulation. In the second step, using condition 20 for a Markov perfect equilibrium, we find the parameters θ that minimize any profitable deviations from the optimal policy as given by the policy functions estimated in the first step.

An innovation we make in our econometric method arises since a firm's own value function $V_i(s;\sigma,\theta)$ depends on the expected value of the value function $EV_j(s;\sigma,\theta)$ of other firms that the firm may acquire or with which the firm may merge. We address the endogeneity of value functions using a fixed point algorithm.

4 Data

We construct a panel data set on the top 50 oil and natural gas producing companies. The original source of data is the Petroleum Intelligence Weekly published by Energy Intelligence Group, which reports annual information on different operational criteria as well as financial and other measures of size for each of the top 50 oil and natural gas producing companies. This data set includes firm-level data on oil and natural gas output, oil and natural gas reserves, product sales, distillation capacity, revenue, net income, total assets, and percentage of state ownership. Each year, the top 50 firms are determined by production as reported in the Petroleum Intelligence Weekly.

The top 50 oil and natural gas producing firms in our data set supply a significant share of global supply of oil. As seen in Figure 1, on average over 70% of the global supply is produced by the top 50 oil and natural gas producing firms in our data set.

We use membership information from the Organization of Petroleum Exporting Countries (OPEC) to construct a dummy variable that takes the value of 1 for a firm if it is a state-owned company owned by an OPEC member state.

We obtain annual oil and natural gas prices from the U.S. Energy Information Administration. We obtain average hourly earning of workers in oil and gas extraction industry from the U.S. Bureau of Labor Statistics.

We also use data on financial indicators averaged over 10 OECD countries as reported in the EU KLEMS database. These indicators include industry rate of return on capital in mining and quarry; average capital compensation on transport equipment in mining and quarry; average capital compensation on other machinery and equipment in mining and quarry; average capital compensation on total non-residential investment in mining and quarry; and average capital compensation on other assets in mining and quarry. Capital compensation is the price of capital times the quantity of capital, which under constant

returns to scale is the value added minus labor compensation. We use capital compensation as our measure of capital costs, including costs of drilling rigs and production platforms, in the oil and gas industry.

We use data on world GDP, world population, world electricity production from oil and natural gas, world road sector fuel consumption, and world motor vehicle from the World Bank.

Unlike the oil market, the natural gas market is not necessarily a global market. Due to the lack of a global pipeline network, the market for natural gas is mostly defined by proximity to supply sources and the availability of a pipeline. In order to estimate separate natural gas demand functions for 6 different regional markets, we have also collected and constructed regional natural gas prices using data from the EIA, and regional population and GDP data from the World Bank. Our 6 regional natural gas markets are the following:

- Africa: The share from global natural gas consumption from Africa, about 2.8%, is the lowest share out of all our 6 regions. Africa is a net importer of natural gas. We use natural gas price data along with natural gas export and import data from Algeria, Egypt, Equatorial Guinea, Libya, Mozambique, and Nigeria to construct an average natural gas price for Africa.

- Asia and Oceania: This region accounts for just below 15% of the global natural gas consumption, and is a net importer of natural gas. We use natural gas price data along with natural gas export and import data from Australia, Brunei, Burma, China, Indonesia, and Malaysia to construct an average natural gas price for Asia and Oceania.

- Eurasia: This region consumes over 20% of the global natural gas consumption and is home to a significant share of natural gas resources, which makes this region a net natural gas exporter. We use natural gas price data along with natural gas export and import data from Azerbaijan, Georgia, Kazakhstan, Russia, Turkmenistan, Ukraine,

and Uzbekistan to construct an average natural gas price for Eurasia.

- Europe: EU countries consume about 20% of the global natural gas consumption with relatively small production, which makes them a net importer. Russia is the major supplier of EU natural gas imports. We use natural gas price data along with natural gas export and import data from EU members and Turkey to construct an average natural gas price for Europe.

- Middle East: The Middle East on average consumes just below 10% of the global natural gas consumption but it is home to a significant natural gas resources in the world, which makes the region a net exporter of natural gas. We use natural gas price data along with natural gas export and import data from Iran, Iraq, Oman, Qatar, UAE, and Yemen to construct an average natural gas price for the Middle East.

- Americas: The North and South America together consume about 32% of the global natural gas consumption and aside from the insignificant liquified natural gas import from outside of the continent its is disconnected from natural gas markets in other parts of the world. Over the last decade the North American natural gas market has been experiencing a boom as a result of the boost in shale gas extraction in the United States. We use natural gas price data along with natural gas export and import data from Canada, Mexico, United States, Argentina, Bolivia, Brazil, Colombia, Peru, and Trinidad and Tobago to construct an average natural gas price for the Americas.

Summary statistics for the action variables, firm-level state variables, and price variables over the years 2000-2005 are presented in Tables 1 to 3; summary statistics for the same variables over the entire period of the data set are in Tables A.1 to A.3 in Appendix A. Summary statistics for the regional and global state variables are in Table 4.

5 Results

5.1 Oil demand

We use annual oil production data of the top 50 producers over the period 1987-2011 along with oil price data to estimate the oil demand equation (2). Because observed equilibrium prices and quantities are simultaneously determined in the supply-and-demand system, instrumental variables are needed to address the endogeneity probelm (Angrist et al., 2000; Goldberger, 1991; Lin Lawell, 2011; Manski, 1995). We instrument for oil price using either real average weekly earnings for support activities in oil and gas extraction or lagged real average weekly earnings for support activities in oil and gas extraction. These variables are supply shifters that affect the costs of producing oil but not demand for oil, and therefore serve as good instruments for oil price. The first-stage F-statistics are over 12 in both specifications of oil demand, and the instruments pass tests of underidentification and weak-instrument-robust inference. Estimation results for oil demand are reported in Table A.4 in Appendix A.

The coefficient on crude oil price is significant and negative in both specifications of the model, which makes sense as it indicates a downward sloping demand curve for crude oil. Demand for oil is increasing with world GDP per capita, which has a significant coefficient in both specifications of the model.

We use specification (2) for our structural model, since using the lagged real average weekly earnings for support activities in oil and gas extraction as an instrument may more convincingly satisfy the exclusion restriction.

5.2 Regional natural gas demand

Unlike the global market for oil, natural gas markets are more regional due to lack of a global natural gas pipeline networks and natural gas prices change regionally. We estimate

six regional natural gas demand functions for Americas, Europe, Eurasia, Middle East, Africa, and Asia & Oceania. We use data on regional natural gas prices and quantity along with regional GDP and population to estimate the regional natural gas demand equation (3) for each region.

We instrument for natural gas prices using average capital compensation and lagged real average weekly earnings for oil and gas extraction as well as support activities in oil and gas extraction, and total natural gas reserves. These variables are supply shifters that affect the costs of producing natural gas but not demand for natural gas, and therefore serve as good instruments for natural gas price.

Tables A.5- A.10 in Appendix A report the estimated results for regional natural gas demand for each region respectively. The first-stage F-statistics as well as the p-values for underidentification, weak-instrument-robust inference, and overidentification tests are also reported. The specifications used in our structural model are indicated with an asterisk. For instance as you can see on the first column of Table A.7, the coefficient for natural gas price is negative and significant for Eurasian natural gas market. The coefficient on regional GDP is also positive and significant for all regions.

The weak instrument robust inference tests test whether the endogenous regressor (i.e., price) is significant. The null hypothesis tested is that the coefficients of the endogenous regressors in the structural equation are jointly equal to zero, and, in addition, that the overidentifying restrictions are valid. Thus, when we pass both the weak instrument robust inference test (p-value ¡0.05) and the overidentification test (p-value > 0.05), as is the case with Eurasia, Europe, and Americas, the coefficient on price is significant.

5.3 Policy functions

Each period, each petroleum producer decides how much oil and natural gas to produce and how much to spend on each type of capital expenditure. Using our panel data on the

top 50 petroleum producers, we estimate policy functions for these decision variables which correlate actions to states. The estimation results are reported in Table A.11 in Appendix A. Since OPEC firms may have different production policies from non-OPEC firms, we estimate the oil and natural gas production policy functions for OPEC firms separately; these results are reported in Table A.12 in Appendix A.

Each firm also decides whether to acquire another firm or be acquired by other firms, and whether to get merged with other firm. In order to estimate the policy function for merger and acquisition decisions we define a merger and acquisition action variable which takes the value of 1 for merger, 2 when a firm acquires another firm, and 0 otherwise. We use a multinomial logit regression model to estimate this policy function. Since OPEC firms and firms that are 100% state-owned never merge or acquire, we exclude these firms from the estimation. Estimation results for policy function on merger and acquisition are reported in Table A.13 in Appendix A. We use specification (4) in the structural estimation.

For firms that do not merge or acquire, these firms may choose to be acquired by another firm. We use a logit regression model to estimate this policy function, once again excluding OPEC firms and firms that are 100% state-owned, since they are never acquired by others, and also excluding firms that merge or acquire. Estimation results for policy function for being acquired are reported in Table A.14 in Appendix A. We use specification (2) in the structural estimation.

5.4 Transition densities

The transition densities for each state variables depend on the lagged value of that state variable and also potentially on the lags of other state variables and lagged actions.

We estimate the transition densities for firm-level oil reserves and natural gas reserves by regressing reserves on lagged reserves, lagged output and lagged capital expenditures, all at the firm level. Similarly we estimate a transition density for percentage of state ownership.

The results are presented in Table A.15 in Appendix A.

In our transition densities for oil and natural gas reserves, we do not assume any fixed finite amount for the reserves. This is consistent with the common practice in the natural resource economics literature of modeling potential reserves as infinite; potential reserves are probably infinite, although the amount that is economical to extract is finite, and technological progress and new discoveries will always make more reserves available and feasible for extraction (Farzin (1992); Lin (2009b). Thus, for the transition densities for oil and natural gas reserves, we regress reserves on lagged reserves, lagged output, and lagged capital expenditures, and we let the data tell us what the transition density is. Our econometric model allows for reserves to increase or decrease over time.

The results for the transition density for world population, which depends on lagged world population, are presented in Table A.16. The results for the transition density for world GDP per capita, which depends on lagged world GDP per capita, are presented in Table A.17 in Appendix A.

The results for the transition density for regional population, which depends on lagged regional population, for each of the 6 regions of the world are presented in Table A.18. The results for the transition density for regional GDP, which depends on lagged regional GDP, for each of the 6 regions of the world are presented in Table A.19 in Appendix A.

The transition densities for average industry rate of return on capital, average capital compensation on other machinery and equipment, average capital compensation on total nonresidential investment, world road sector gasoline fuel consumption, world motor vehicles, world electricity production from natural gas sources, and world road sector gasoline from oil sources are in Tables A.20 to A.26, respectively, in Appendix A. For each state variable, we regressed the state variable on the lagged value of the state variable, as well as on the lagged values of other relevant state variables and lagged values of aggregate reserves and aggregate production variables. In some cases, relevant state variables were dropped due to

collinearity.

The lagged values of aggregate reserves and aggregate production are significant in most transition densities, which means that the investment and production decisions of other firms affect the future values of state variables which affect a firm's future payoff from producing and investing, and therefore that firms must anticipate the production and investment strategies of other firms in order to make a dynamically optimal decision. There is thus an important strategic component for firms' production and investment decisions.

5.5 Structural parameters

The parameters θ we estimate include the production profit parameters δ, the merger fixed cost parameters λ, the acquisition fixed cost parameters γ_1 and the selling value parameters γ_2. We set the discount factor β to 0.9.

Our parameter estimates are presented in Table 5, and our estimates of the merger and acquisition costs are presented in Table 6. Welfare and production profits for all firms, OPEC firms, and non-OPEC firms are presented in Table 7.

While our model allows firms that are at least partially state-owned to have different objectives from private firms, we find that state-owned firms do not put any weight on consumer surplus, as we estimate ρ_{CS} to be a precise zero.

Summary statistics of the action variables simulated by our structural econometric model are presented in Table 8. When compared with the summary statistics of the actual values of the action variables observed in the data in Table 1, it appears that our structural econometric model does a fairly good job matching the actual data.

Summary statistics of the price variables simulated by our structural econometric model are presented in Table 9. When compared with the summary statistics of the actual values of the price variables observed in the data in Table 3, it appears that our structural econometric model does a fairly good job matching the actual data.

6 Counterfactual simulations

We use the estimated parameters from our structural econometric model to run counterfactual simulations to analyze the effects of changes in OPEC membership, the privatization of state-owned oil companies, a ban on mergers, and demand shocks on the petroleum industry over the period 2000-2005. For each counterfactual scenario, we compare the results from that counterfactual scenario with the results from the base-case status quo simulation of no counterfactual change in Tables 7-9.

6.1 OPEC membership scenarios

For our counterfactual OPEC membership scenarios, we simulate changes in OPEC membership and new potential entry and exit into and from OPEC. In particular, we simulate the following 2 OPEC membership scenarios:

1. All firms are members of OPEC.

2. No firms are members of OPEC.

As seen in Table B.1, when compared to the base-case status quo simulation, welfare is higher under first OPEC membership case where all firms are members of OPEC in it is lower under OPEC membership case 6 where no firms are members of OPEC. Under case 2 where all state-owned firms (i.e., firms that are 100% state-owned) are members of OPEC both OPEC and non-OPEC firms have higher total and average welfare. This is also the case for membership cases 3-5 where all firms experience statistically significant increases in welfare. The average production profit for OPEC firms declines under all the membership case scenarios 1-5. Non-OPEC firms experience statistically significant increase in all but membership case 3 where production profit for non-OPEC firms decline.

As seen in Tables B.2-B.3, when compared to the base-case status quo simulation, under

membership case 1 where all firms are OPEC members, oil and natural gas production, as well as exploration and development capex are significantly lower for OPEC members. The acquisition capex increases relative to the base case simulation under first OPEC membership case. Under the OPEC membership case 2 (i.e., firms that are 100% state-owned are members of OPEC) OPEC firms have significantly lower production of both oil and natural gas. The capex is also significantly lower for OPEC firms in this case. Non OPEC firms on the other hand have higher natural gas production and spend more on development and acquisition capex but produce less oil and spend less on exploration capex compared to the base-case status quo simulation. There is also more merger and acquisition under OPEC membership case 2.

Oil and natural gas production as well as exploration and development capex are significantly lower for both both OPEC and non-OPEC firms under OPEC membership case 3 (i.e., firms that are $> 0\%$ state-owned are members of OPEC) relative to the base-case status quo simulation. Both OPEC and non-OPEC firms spend less on acquisition capex relative to the base-case simulation under this OPEC membership case. And merger and acquisition activity is also higher under this counterfactual scenario.

Under membership cases 4, 5, and 6 there are more production of oil and natural gas and higher capex on exploration and development relative to the base-case status quo simulation for non-OPEC firms. The opposite is the case for OPEC firms under OPEC membership cases 4 and 5. The acquisition capex is lower for non-OPEC firms and higher for OPEC firms under these OPEC membership case. There are also less merger and acquisition under these cases. all the differences are statistically significant at a 5% significance level.

As seen in Tables B.4, when compared to the base-case status quo simulation, natural gas prices for Africa, Eurasia, and America are higher under the first member ship case and no other prices are changing significantly under this case. Under the OPEC membership case simulation where no firms are in OPEC where no firms are members of OPEC price of

oil and natural gas in all regions but Africa, Asia & Oceania, and Europe are lower relative to the base-case status quo simulation.

Including all firms in OPEC will increase firm welfare and decrease oil production.

Not including any firms in OPEC will decrease firm welfare ; increase oil production and decrease oil price, as expected; and increase natural gas production and decrease some regional natural gas prices.

Including all the private firms in OPEC but not including any firms that have any state ownership will increase welfare for private firms (which are now all in OPEC) but decrease welfare for non-OPEC firms. As expected, it will decrease oil production among private firms (which are now all in OPEC). It will also decrease natural gas production among private firms (which are now all in OPEC); increase oil and natural gas production among non-OPEC firms; and decrease oil price and most regional natural gas prices

6.2 Privatization scenarios

We simulate the following alternative privatization scenarios:

1. percentage state ownership=0 (all firms privatized)

2. percentage state ownership=50 (each firm is 50% state-owned)

3. percentage state ownership=100 (each firm is 100% state-owned)

Privatizing all firms decreases average welfare and average production profit for both OPEC and non-OPEC firms; and increases the minimum production profit for both OPEC and non-OPEC firms. Making all firms 50% state-owned decreases average welfare for OPEC firms; increases average welfare for non-OPEC firms; decreases average production profit for both OPEC and non-OPEC firms; and increases the minimum production profit for both OPEC and non-OPEC firms. Making all firms 100% state-owned increases welfare and

production profits for OPEC firms; decreases average welfare for non-OPEC firms; and increases maximum welfare for non-OPEC firms.

As seen in Table B.5, both welfare and production profits are lower for both OPEC and non-OPEC firms under zero state ownership scenario. Under 50% state ownership scenario welfare is lower for OPEC firms and higher for non-OPEC firms compared to the base-case status quo simulation. Production profit for both OPEC and non-OPEC firms decline under 50% state ownership scenario. Under 100% state ownership scenario when compared to the base-case status quo simulation, Production profit for both OPEC and non-OPEC firms increase but welfare increases for OPEC firms and declines for non OPEC firms. All the changes are statistically significant at least at 5% significance level.

As seen in Tables B.6-B.8, when compared to the base-case status quo simulation, under complete privatization (zero state ownership) oil and natural gas production is lower for non-OPEC firms; all three types of capex is higher for OPEC and non-OPEC firms; and there are more mergers and acquisition activities among non-OPEC firms. As the percentage of state ownership increases the capital expenditure decreases for non-OPEC firms relative to the base case and the effect on capital expenditure of the OPEC firms is mixed. Higher percentage of state ownership also results in less mergers and acquisition relative to the base-case status quo simulation.

As seen in Table B.9, when compared to the base-case status quo simulation, natural gas prices for all regions but Middle East are lower under zero state ownership scenario and higher as percentage of state ownership increases. Non of the other prices change significantly relative to the base-case under any privatization scenario.

Privatizing all firms will increase welfare.

Making all firms 100% state-owned will decrease welfare.

6.3 Ban on mergers

Banning mergers will increase welfare for OPEC firms; decrease welfare and oil and natural gas production for non-OPEC firms; and increase total and average production profit for all firms, OPEC firms, and non-OPEC firms.

As seen in Table B.10, welfare and production profits are higher for OPEC firms and lower for non-OPEC firms under the merger ban simulation when compared to the base-case status quo simulation, and the differences are statistically significant at a 5% significance level.

As seen in Table B.11 when compared to the base-case status quo simulation, oil and natural gas production, as well as all types of capital expenditure are lower for non-OPEC firms; acquisition capex is higher for OPEC firms; and there are fewer mergers and more acquisitions under merger ban simulation.

As seen in Table B.12, when compared to the base-case status quo simulation,under merger ban natural gas prices for Africa, Asia & Oceania, and Europe are lower. None of the other prices change significantly relative to the base-case under merger ban scenario.

Banning mergers will increase welfare and possibly production profit as well.

6.4 Demand shock

For this counter-factual simulation, we multiply a demand shock, which is a set of shocks to oil demand and natural gas demand for each region r to the constant in the oil and natural gas demand functions, respectively, so that:

- The constant in the oil demand function in equation (2) changes from α_{10} to $\alpha_{10} \times$ oil_shock
- The constant in the natural gas demand function for each region r in equation (3) changes from α_{20} to $\alpha_{20} \times$ ng_shock_r

We simulate the following demand shock scenarios:

1. oil_shock = 0.90 and ng_shock_r = 0.90 for each r

2. oil_shock = 0.75 and ng_shock_r = 0.75 for each r

3. oil_shock = 0.90 and ng_shock_r = 1 for each r (all set equal to 1)

4. oil_shock = 0.75 and ng_shock_r = 1 for each r (all set equal to 1)

5. oil_shock = 1 and ng_shock_r = 0.75 for each r, one at a time (for a total of 6 scenarios)

6. oil_shock = 1 and ng_shock_r = 1.25 for each r, one at a time (for a total of 6 scenarios)

As seen in Tables B.13-B.15, under first demand shock scenario we do not see any significant change in welfare and production profits compared to the base-case status quo simulation, but other demand shock scenarios have a mix of positive and negative effect on welfare and production profits and the differences are statistically significant at a 5% significance level.

As seen in Tables B.16 when compared to the base-case status quo simulation, we see no significant effect on any of the action variables under the first demand shock scenario.

As seen in Tables B.17 under second demand shock scenario when compared to the base-case status quo simulation, non OPEC firms' natural gas production, development and acquisition cost decline while they spend more on exploration capex. The effect on mergers and acquisition is mixed. The effect on OPEC firms on the other hand expected to increase the values for all the action variables but oil production.

Under demand shock scenario 3 in table B.18 oil production increases for OPEC firms and decreases for non-OPEC firms while natural gas production increases for both OPEC and non-OPEC firms. The effect on different types of capital expenditure and merger and acquisition is mixed.

Under demand shock scenario 4 in table B.19, OPEC firms reduce production of both oil and natural gas and spend more on capital expenditure. Non-OPEC firms on the other hand produce more oil but less natural gas and spend less on development and acquisition capex. The effect on mergers is small and positive while the number of acquisitions decreases.

Under demand shock scenarios 5 through 10 we assume no oil demand shock and a 0.75 natural gas demand shock for one region at a time. As seen in tables B.20-B.25 under most regional natural gas demand shocks OPEC firms reduce both oil and natural gas production and non-OPEC firms increase their oil output while reducing their natural gas output. The effect on capital expenditure and merger & acquisition is mix.

Under demand shock scenarios 11 through 16 we assume no oil demand shock and a 1.25 natural gas demand shock for one region at a time. As seen in tables B.26-B.31 there is a mix of positive and negative effect on action variables from a similar natural gas demand shock on different regions.

As seen in Table B.32, when compared to the base-case status quo simulation, under different demand shock scenarios we see no significant effect on the price of oil but a mix of positive and negative effects on regional natural gas prices.

Shocks to oil and/or natural gas demand may increase or decrease welfare.

7 Conclusions

Results from counterfactual simulations:

Including all firms in OPEC will increase firm welfare.

Not including any firms in OPEC will decrease firm welfare.

Privatizing all firms decreases average welfare and average production profit for both OPEC and non-OPEC firms; and increases the minimum production profit for both OPEC and non-OPEC firms. Making all firms 50% state-owned decreases average welfare for OPEC

firms; increases average welfare for non-OPEC firms; decreases average production profit for both OPEC and non-OPEC firms; and increases the minimum production profit for both OPEC and non-OPEC firms. Making all firms 100% state-owned increases welfare and production profits for OPEC firms; decreases average welfare for non-OPEC firms; and increases maximum welfare for non-OPEC firms.

Banning mergers will increase welfare for OPEC firms; decrease welfare and oil and natural gas production for non-OPEC firms; and increase total and average production profit for all firms, OPEC firms, and non-OPEC firms.

Shocks to oil and/or natural gas demand may increase or decrease welfare.

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8 Figures and Tables

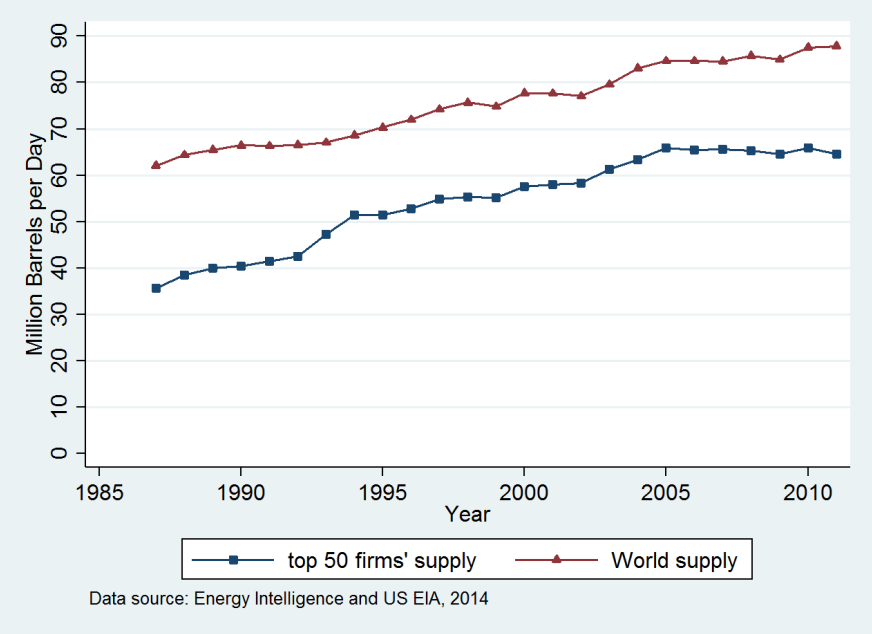

Figure 1: World oil supply vs top 50 producers supply in MMBD

Table 1: Summary statistics for action variables (2000-2005)

Variable	# Obs	Mean	Std. Dev.	Min	Max
Oil output (KBD)	300	1214.441	1466.5487	11	11035
Natural gas output (MCFD)	300	3445.546	7242.888	44	53135
Exploration capex (million 2005 US$)	94	595.9822	453.5993	-13.232	1828.14
Development capex (million 2005 US$)	94	2640.832	2268.744	0	9045
Acquisition capex (million 2005 US$)	93	1133.271	2651.709	-142.899	17625
Dummy for M&A at time t					
merging with another firm	300	.0133	.1149	0	1
acquiring another firm	300	.0233	.1512	0	1
being acquired by another firm	300	.0167	.1282	0	1
OPEC firms' production only					
Oil output (KBD)	67	2445.269	2324.396	135	11035
Natural gas output (MCFD)	67	3419.313	2687.751	112	8485
Non-OPEC firms' production only					
Oil output (KBD)	233	860.5119	819.4949	11	3754
Natural gas output (MCFD)	233	3453.09	8096.542	44	53135

Table 2: Summary statistics for firm level state variables (2000-2005)

Variable	# Obs	Mean	Std. Dev.	Min	Max
OPEC membership at time t (dummy)	300	.2233333	.4171758	0	1
State ownership (in percentage)	300	48.48641	45.74817	0	100
Oil reserves (million barrels)	300	19820.82	44090.61	50	264200
Natural gas reserves (BCF)	300	85529.82	207369.9	420	1320000

Table 3: Summary statistics for prices of oil and natural gas (2000-2005)

Variable	# Obs	Mean	Std. Dev.	Min	Max
Crude oil price, Brent (2005 US$/bbl)	6	35.98517	9.791585	28.7883	54.4341
Natural gas price, US (2005 US$/mmbtu)	6	5.756597	1.755797	3.97939	8.91567
Regional natural gas price (2005 US$/mmbtu)					
Africa	5	5.643	2.4304	3.3171	9.679
Asia & Oceania	5	9.7815	1.4431	8.2034	11.764
Eurasia	5	0.9509	0.2714	0.7106	1.3715
Europe	5	7.1918	1.8749	5.1571	9.7842
Middle East	5	6.263	1.0773	5.3768	8.1295
America	5	5.8928	1.8119	3.9221	8.5541

Table 4: Summary statistics for state variables

Variable	# Obs	Mean	Std. Dev.	Min	Max
Avg capital compensation (million 2005 US$)					
on transport equipment	24	132.322	57.204	21.891	243.422
on other machinery and equipment	24	2086.081	870.891	415.203	4141.958
on total non-residential investment	24	4078.227	2371.123	847.457	10639.06
Average industry rate of return on capital	24	.144	.04	.08	.232
World GDP per capita (2005 US$)	25	6475.482	691.679	5456.522	7642.35
World population (million people)	25	5970.799	575.621	4985.892	6942.765
World electricity production (kWh)					
from oil sources	25	1.04e+12	1.02e+11	8.08e+11	1.19e+12
from natural gas sources	25	2.71e+12	1.17e+12	8.28e+11	4.85e+12
World road sector gasoline					
fuel consumption (kt of oil equivalent)	18	827537.6	50057.57	730584	898004
World motor vehicles (per 1,000 people)	10	156.73	11.225	142.4	180.18
Average weekly earnings (2005 US$)					
for oil and gas extraction	25	892.2796	65.31246	803.238	1023.57
for supporting activities in oil and gas	22	789.4748	92.58307	681.1732	978.1636
Regional GDP (trillion 2005 US$)					
Africa	25	0.817	0.507	0.408	2.13
Asia and Oceania	25	9.19	4.3	3.81	20.7
Eurasia	25	0.871	0.691	0.0722	2.6
Europe	25	11.9	4.68	5.59	20.8
Middle East	25	0.885	0.622	0.304	2.52
Americas	25	13.3	5.15	6.1	23.2
Regional population (million people)					
Africa	25	797	144	578	1050
Asia and Oceania	25	3340	321	2780	3820

Table 4: (continued)

Variable	# Obs	Mean	Std. Dev.	Min	Max
Eurasia	25	287	2.548955	281	291
Europe	25	574	18.6	540	604
Middle East	25	168	30.2	120	221
Americas	25	823	80.3	689	948

Table 5: Estimated parameters and standard errors

Description		Estimated parameters
Coefficient in oil production cost on:		
Oil production (KBD*1e-4)	δ_{11}	-1.9430 ***
		(0.0487)
Oil production squared	δ_{12}	1.3433 ***
		(0.0329)
Oil reserves (bbl)	δ_{13}	4.9555 ***
		(0.1057)
Oil production × Oil reserves	δ_{14}	-1.5178 ***
		(0.0275)
Coefficient in natural gas production cost on:		
NG production (MCF*1e-4)	δ_{21}	0.2216 ***
		(0.0071)
NG production squared	δ_{22}	-0.0697 ***
		(0.0019)
NG reserves (KCF)	δ_{23}	-1.1436 ***
		(0.0361)
NG production × NG reserves	δ_{24}	-0.4393 ***
		(0.0177)
Coefficient in per-period payoff on:		
Percentage of state ownership	ω_1	2.0329 ***
		(0.0630)
OPEC member (dummy)	ω_2	10.4429 ***
		(0.2780)
EV of other firm if acquire (billion $)	η_1	0.7965 ***
		(0.0066)
EV of other firm if merge (billion $)	η_2	0.7637 ***
		(0.0100)
Percent state ownership × Consumer surplus (billion $)	ρ_{CS}	0.0000 ***
		(0.0000)
Constant	δ_0	0.0000 ***
		(0.0000)

Notes: Per period payoffs are in billion dollars. Standard errors in parentheses.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 6: Estimates of mean and standard deviation of merger and acquisition costs

Description	Estimation	Standard Errors
Cost of		
being acquired, mean	0.1152^{***}	0.0038
being acquired, std. dev.	0.2200^{***}	0.0048
acquiring, mean	0.2810^{***}	0.0080
acquiring, std. dev.	0.3920^{***}	0.0093
merger, mean	0.5145^{***}	0.0113
merger, std. dev.	0.6890^{***}	0.0130

Note: Per period payoffs are in billion dollars. Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 7: Welfare

Variable	All firms	OPEC firms	Non-OPEC firms
Expected total welfare	95.9250 **	51.7588 ***	44.1662
	(29.5244)	(2.6602)	(27.1950)
Expected avg. welfare	1.9185 **	4.5749 ***	1.1406
	(0.5905)	(0.2350)	(0.7031)
Min welfare	-0.5832	0.2540	-0.5832
	(0.8018)	(0.1335)	(0.7818)
Max welfare	6.8677 ***	6.8677 ***	2.2552 **
	(0.2247)	(0.2247)	(0.6959)
Expected total production profit	15.4550 ***	6.5132 ***	8.9418 **
	(4.5483)	(1.2904)	(3.2602)
Expected avg. production profit	0.3091 ***	0.5851 ***	0.2299 **
	(0.0910)	(0.1142)	(0.0842)
Min production profit	-0.1590	0.0035	-0.1761 *
	(0.0887)	(0.0375)	(0.0790)
Max production profit	4.7864 ***	1.5316 ***	4.7864 ***
	(0.2577)	(0.1286)	(0.2577)

Notes: Welfare and production profit are in billions of dollars per year. Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 8: Summary statistics for simulated action variables

Variable	All firms		OPEC firms		Non-OPEC firms	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Oil output (KBD)	1503.514 ***	1796.073 ***	2512.852 ***	2562.346 ***	1028.842 ***	967.779 ***
	(43.788)	(71.594)	(160.515)	(113.881)	(11.299)	(8.659)
Natural gas output (MCFD)	3874.760 ***	7502.254 ***	3336.468 ***	3383.802 ***	4135.609 ***	8784.601 ***
	(155.890)	(103.774)	(231.449)	(141.766)	(122.972)	(124.555)
Capital expenditure on						
Exploration (million 2005 US$)	679.122 ***	897.901 ***	1126.927 ***	1139.218 ***	466.955 ***	657.581 ***
	(19.319)	(9.175)	(35.132)	(10.234)	(20.062)	(11.838)
Development (million 2005 US$)	1832.241 ***	2577.189 ***	3091.026 ***	3421.532 ***	1232.528 ***	1766.299 ***
	(22.778)	(21.113)	(84.241)	(28.691)	(15.390)	(18.242)
Acquisition (million 2005 US$)	776.833 ***	1376.407 ***	499.663 ***	954.628 ***	908.868 ***	1517.305 ***
	(19.530)	(26.413)	(8.003)	(8.435)	(27.168)	(32.139)
Dummy for M&A at time t						
merging	0.174 ***	0.379 ***			0.225 ***	0.418 ***
	(0.002)	(0.001)			(0.001)	(0.001)
acquiring another firm	0.048 ***	0.212 ***			0.062 ***	0.240 ***
	(0.004)	(0.009)			(0.005)	(0.010)
being acquired by another firm	0.003 ***	0.036 ***			0.003 ***	0.041 ***
	(0.000)	(0.002)			(0.000)	(0.003)

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 9: Summary statistics for price

Price	Mean	Std. Dev.
Crude oil price, Brent (2005 US$/bbl)	70.5065 ***	0.0000
	(0.0000)	(0.0000)
Regional natural gas price (2005 US$/mmbtu)		
Africa	8.5303 ***	2.6513 ***
	(0.0339)	(0.0196)
Asia & Oceania	12.1559 ***	5.1813 ***
	(0.2106)	(0.0186)
Eurasia	2.0876 ***	0.1211 ***
	(0.0143)	(0.0351)
Europe	6.2775 ***	2.6986 ***
	(0.0659)	(0.1406)
Middle East	11.1239 ***	4.7419 ***
	(0.1049)	(0.0465)
America	9.6838 ***	2.5450 ***
	(0.0516)	(0.1264)

Notes: Standard errors in parentheses.

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 10: Changes in welfare from base case under different OPEC membership cases

	All firms	OPEC firms	Non-OPEC firms
OPEC membership case where all firms are members of OPEC			
Expected total welfare	174.2428 ***	218.4090 ***	
Expected avg welfare	3.4848 ***	0.8285 ***	
Min welfare	-0.1048 ***	-0.2134 ***	
Max welfare	0.2955 ***	0.2955 ***	
Expected total production profit	-3.2619 ***	5.6799 ***	
Expected avg production profit	-0.06523 ***	-0.3412 ***	
Min production profit	-0.0229 ***	0.0308 ***	
Max production profit	-3.0392 ***	0.2155 ***	
OPEC membership case where no firms are members of OPEC			
Expected total welfare	-145.0173 ***		-93.2585 ***
Expected avg welfare	-2.9003 ***		-2.1224 ***
Min welfare	-3.5009 ***		-3.5009 ***
Max welfare	-6.531 ***		-1.9185 ***
Expected total production profit	4.543269 ***		11.0565 ***
Expected avg production profit	0.0909 ***		0.1700 ***
Min production profit	-0.07551 ***		-0.0584 ***
Max production profit	0.1881 ***		0.1881 ***

Notes: Welfare is in billions of dollars per year.

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 11: Change in action variables from base case under different OPEC membership cases

	All firms	OPEC firms	Non-OPEC firms
OPEC membership case where all firms are members of OPEC			
Oil output (KBD)	-319.263***	-1328.6017 ***	
Natural gas output (MCFD)	-1725.358 ***	-1187.0649 ***	
Exploration capex (2005 US$)	-139.605***	-587.4101 ***	
Development capex (2005 US$)	-394.919 ***	-1653.7030 ***	
Acquisition capex (2005 US$)	-257.944***	19.2263 ***	
merging			
acquiring another firm			
being acquired by another firm			
OPEC membership case where no firms are members of OPEC			
Oil output (KBD)	87.600***		562.2722 ***
Natural gas output (MCFD)	2175.249 ***		1914.4008 ***
Exploration capex (2005 US$)	77.638 ***		289.8049 ***
Development capex (2005 US$)	111.233 ***		710.9460 ***
Acquisition capex (2005 US$)	-27.942 ***		-159.9773
merging	0.032 ***		-0.0187 ***
acquiring another firm	-0.010 ***		-0.0245 ***
being acquired by another firm	0.001 ***		-0.0002 ***

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 12: Change in prices from base case under different OPEC membership cases

OPEC membership case where all firms are members of OPEC	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	0.0884 ***
Asia & Oceania	0.2048
Eurasia	0.0494 ***
Europe	0.0128
Middle East	-0.0598
America	0.2909 *
OPEC membership case where no firms are members of OPEC	
Crude oil price, Brent (2005 US$/bbl)	-1.9264 ***
Regional natural gas price (2005 US$/mmbtu)	
Africa	-0.1272
Asia & Oceania	0.1937
Eurasia	-0.1969 ***
Europe	-0.0576
Middle East	-0.1412
America	-0.3249 ***

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 13: Changes in welfare from base case under different privatization scenarios

	All firms	OPEC firms	Non-OPEC firms
State ownership=0%			
Expected total welfare	-110.9084 ***	-17.7357 ***	-93.1726 ***
Expected avg welfare	-2.2182 ***	-1.5654 ***	-2.4091 ***
Min welfare	-3.3575 ***	-0.2005 ***	-3.3575 ***
Max welfare	-1.4430 ***	-1.4430 ***	-2.2552 ***
Expected total production profit	-2.5077 ***	-0.6589 ***	-1.8487 ***
Expected avg production profit	-0.0502 ***	-0.0583 ***	-0.0478 ***
Min production profit	-0.0243 **	0.0345 ***	0.0128 *
Max production profit	-0.9160 ***	-0.0568 ***	-0.9160 ***
State ownership=50%			
Expected total welfare	83.1996 ***	-8.5238 ***	91.7234 ***
Expected avg welfare	1.6640 ***	-0.7523 ***	2.3709 ***
Min welfare	0.1791 ***	-0.1519 ***	0.5832 ***
Max welfare	0.2455 ***	-0.6089 ***	4.5789 ***
Expected total production profit	-2.1589 ***	-0.4588 ***	-1.7001 ***
Expected avg production profit	-0.0432 ***	-0.0410 ***	-0.0438 ***
Min production profit	-0.0145	0.0501 ***	0.0262 ***
Max production profit	-0.8956 ***	-0.0350 **	-0.8956 ***
State ownership=100%			
Expected total welfare	-8.9486 ***	1.7872 ***	-10.7358 ***
Expected avg welfare	-0.1790 ***	0.1586 ***	-0.2801 ***
Min welfare	-0.9867 ***	0.0746 ***	-0.9867 ***
Max welfare	1.0882 ***	0.2795 ***	4.6744 ***
Expected total production profit	0.9274	0.4952 ***	0.4322
Expected avg production profit	0.0185	0.0444 ***	0.0108
Min production profit	-0.0587 ***	0.0252 ***	-0.0545 ***
Max production profit	0.9502 ***	0.0483 ***	0.9502 ***

Notes: Welfare is in billions of dollars per year.

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 14: Change in action variables from base case under different privatization scenarios

	All firms	OPEC firms	Non-OPEC firms
State ownership=0%			
Oil output (KBD)	-22.7503 ***	-4.5908	-62.1749 ***
Natural gas output (MCFD)	-80.4565 ***	7.3128	-106.8626 ***
Exploration capex (2005 US$)	95.1802 ***	156.5612 ***	50.5509 ***
Development capex (2005 US$)	168.7138 ***	307.0516 ***	60.0540 ***
Acquisition capex (2005 US$)	13.4184 ***	0.6334	28.1557 ***
merging	0.0104 ***		0.0135 ***
acquiring another firm	0.0010 **		0.0013 **
being acquired by another firm	-0.0004 ***		-0.0005 ***
State ownership=50%			
Oil output (KBD)	26.3717 ***	6.8902	6.1159 ***
Natural gas output (MCFD)	-231.2610 ***	14.9494	-337.0544 ***
Exploration capex (2005 US$)	0.6733	71.4157 ***	-48.4966 ***
Development capex (2005 US$)	-9.1421 ***	142.1646 ***	-123.7514 ***
Acquisition capex (2005 US$)	2.0057	18.3418 ***	1.9591
merging	0.0117 ***		0.0152 ***
acquiring another firm	-0.0036 ***		-0.0046 ***
being acquired by another firm	-0.0002 ***		-0.0002 ***
State ownership=100%			
Oil output (KBD)	-226.4122 ***	-6.4059	-107.3858 ***
Natural gas output (MCFD)	-965.9086 ***	8.1612	-1350.0610 ***
Exploration capex (2005 US$)	-215.7908 ***	-16.1492 ***	-192.5946 ***
Development capex (2005 US$)	-531.3779 ***	-22.6045 **	-449.2526 ***
Acquisition capex (2005 US$)	-257.9439 ***	2.7358 ***	-385.2302 ***
merging			
acquiring another firm			
being acquired by another firm			

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 15: Change in prices from base case under different privatization scenarios

State ownership=0%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	-4.1494 ***
Asia & Oceania	-0.6311 ***
Eurasia	-0.1883 ***
Europe	-0.1089 **
Middle East	0.0272
America	-4.4658 ***
State ownership=50%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	0.0884 ***
Asia & Oceania	5.9896 ***
Eurasia	0.0494 ***
Europe	3.6881 ***
Middle East	0.1195
America	1.0390 ***
State ownership=100%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	0.0884 ***
Asia & Oceania	6.0007 ***
Eurasia	0.0494 ***
Europe	3.6305 ***
Middle East	-0.0598
America	1.0390 ***

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 16: Changes in welfare from base case under merger ban

	All firms	OPEC firms	Non-OPEC firms
Expected total welfare	-77.0060 ***	0.4680 **	-77.4741 ***
Expected avg welfare	-1.5401 ***	0.0416 **	-2.0037 ***
Min welfare	-2.5911 ***	0.0775 ***	-2.5911 ***
Max welfare	-0.0223	-0.0223	-1.5673 ***
Expected total production profit	1.4544 **	0.4996 ***	0.9548 **
Expected avg production profit	0.0291 **	0.0445 ***	0.0242 **
Min production profit	-0.0399 ***	0.0376 ***	-0.0442 ***
Max production profit	0.9132 ***	0.0466 ***	0.9132 ***

Notes: Welfare is in billions of dollars per year.

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 17: Change in action variables from base case under merger ban

	All firms	OPEC firms	Non-OPEC firms
Oil output (KBD)	-264.1892 ***	2.6845	-168.5807 ***
Natural gas output (MCFD)	-656.6270 ***	-0.0668	-948.6920 ***
Exploration capex (2005 US$)	-122.3981 ***	-2.4409	-80.0775 ***
Development capex (2005 US$)	-338.3555 ***	-3.0295	-217.8601 ***
Acquisition capex (2005 US$)	-59.7314 ***	6.5940 ***	-128.4695 ***
merging			
acquiring another firm	0.0162 ***		0.0210 ***
being acquired by another firm	0.0060 ***		0.0078 ***

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 18: Change in prices from base case under merger ban

Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	-0.1944 **
Asia & Oceania	-0.4705 ***
Eurasia	0.0011
Europe	-0.1473 **
Middle East	-0.0163
America	-0.0113

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 19: Changes in welfare from base case under different demand shocks

	All firms	OPEC firms	Non-OPEC firms
1: Constant in both oil and all regional natural gas demand functions decreases by 10%			
Expected total welfare	1.1069	0.0018	1.1051
Expected avg welfare	0.0221	0.0002	0.0286
Min welfare	0.0116	0.0002	0.0116
Max welfare	0.0001	0.0001	0.0966
Expected total production profit	0.0000	0.0000	0.0000
Expected avg production profit	0.0000	0.0000	0.0000
Min production profit	0.0000	0.0000	0.0000
Max production profit	0.0000	0.0000	0.0000
2: Constant in both oil and all regional natural gas demand functions decreases by 25%			
Expected total welfare	28.8711 ***	-0.8540 ***	29.7252 ***
Expected avg welfare	0.5774 ***	0.0528 ***	0.7541 ***
Min welfare	0.7355 ***	0.1114 ***	0.5832 ***
Max welfare	0.1226 ***	0.1226 ***	0.9986 ***
Expected total production profit	7.7164 ***	2.1873 ***	5.5291 ***
Expected avg production profit	0.1543 ***	0.2059 ***	0.1411 ***
Min production profit	0.1722 ***	0.1763 ***	0.1735 ***
Max production profit	0.3614 ***	0.1835 ***	0.3614 ***
3: Constant in oil demand function decreases by 10%			
Expected total welfare	8.3196 ***	-0.6769 ***	8.9965 ***
Expected avg welfare	0.1664 ***	0.0689 ***	0.2226 ***
Min welfare	0.0539	-0.0354 **	0.0539
Max welfare	0.0027	0.0027	0.5442 ***
Expected total production profit	1.8255 ***	1.1170 ***	0.7085 *
Expected avg production profit	0.0365 ***	0.1086 ***	0.0175 *
Min production profit	0.0213 **	0.0031	0.0224 ***
Max production profit	-0.0544 *	0.1262 ***	-0.0544 *
4: Constant in oil demand function decreases by 25%			
Expected total welfare	-1.5363	-0.0007	-1.5356
Expected avg welfare	-0.0307	-0.1307 ***	-0.0317
Min welfare	0.3304 ***	-0.2442 ***	0.2078 ***
Max welfare	0.0024	0.0024	-0.3056 ***

Notes: Welfare is in billions of dollars per year.

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 19: (continued)

	All firms	OPEC firms	Non-OPEC firms
Expected total production profit	0.2671	-0.6429 ***	0.9100 **
Expected avg production profit	0.0053	-0.0650 ***	0.0238 **
Min production profit	0.0004	0.0594 ***	-0.0205 ***
Max production profit	-0.0970 ***	-0.1026 ***	-0.0970 ***

Notes: Welfare is in billions of dollars per year.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 20: Changes in welfare from base case under different demand shocks

	All firms	OPEC firms	Non-OPEC firms
5: Constant in natural gas demand function for Africa decreases by 25%			
Expected total welfare	44.1122 ***	-0.3302 *	44.4424 ***
Expected avg welfare	0.8822 ***	0.1004 ***	1.1314 ***
Min welfare	1.0757 ***	0.0910 ***	0.5832 ***
Max welfare	0.2411 ***	0.2411 ***	1.4572 ***
Expected total production profit	12.7094 ***	3.4451 ***	9.2643 ***
Expected avg production profit	0.2542 ***	0.3202 ***	0.2369 ***
Min production profit	0.2576 ***	0.1561 ***	0.1761 ***
Max production profit	0.6761 ***	0.2834 ***	0.6761 ***
6: Constant in natural gas demand function for Asia & Oceania decreases by 25%			
Expected total welfare	14.4314 ***	-0.8769 ***	15.3083 ***
Expected avg welfare	0.2886 ***	-0.0793 ***	0.3952 ***
Min welfare	0.6438 ***	0.1608 ***	0.3858 ***
Max welfare	0.0356 *	0.0356 *	0.2210 ***
Expected total production profit	5.9721 ***	1.1398 ***	4.8323 ***
Expected avg production profit	0.1194 ***	0.1034 ***	0.1239 ***
Min production profit	0.1373 ***	0.0663 ***	0.0804 ***
Max production profit	0.4023 ***	0.0574 ***	0.4023 ***
7: Constant in natural gas demand function for Eurasia decreases by 25%			
Expected total welfare	68.0342 ***	-0.0171	68.0513 ***
Expected avg welfare	1.3607 ***	0.1289 ***	1.7368 ***
Min welfare	1.3768 ***	0.4819 ***	0.5832 ***
Max welfare	0.4037 ***	0.4037 ***	2.2345 ***

Notes: Welfare is in billions of dollars per year.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 20: (continued)

	All firms	OPEC firms	Non-OPEC firms
Expected total production profit	20.4804 ***	5.5349 ***	14.9455 ***
Expected avg production profit	0.4096 ***	0.5102 ***	0.3826 ***
Min production profit	0.3796 ***	0.4794 ***	0.1761 ***
Max production profit	0.9590 ***	0.4588 ***	0.9590 ***
8: Constant in natural gas demand function for Europe decreases by 25%			
Expected total welfare	26.8037 ***	-1.1945 ***	27.9982 ***
Expected avg welfare	0.5361 ***	0.0219	0.7098 ***
Min welfare	0.7308 ***	0.0459 ***	0.4165 ***
Max welfare	0.1575 ***	0.1575 ***	0.8633 ***
Expected total production profit	9.1318 ***	2.5382 ***	6.5936 ***
Expected avg production profit	0.1826 ***	0.2378 ***	0.1684 ***
Min production profit	0.1794 ***	0.0122 *	0.1066 ***
Max production profit	0.6330 ***	0.2072 ***	0.6330 ***
9: Constant in natural gas demand function for Middle East decreases by 25%			
Expected total welfare	-9.2181 ***	-1.3224 ***	-7.8957 ***
Expected avg welfare	-0.1844 ***	-0.1204 ***	-0.2039 ***
Min welfare	-0.0027	-0.0064	-0.0027
Max welfare	-0.0631 ***	-0.0631 ***	-0.1859 **
Expected total production profit	-1.7990 ***	-0.7594 ***	-1.0396 **
Expected avg production profit	-0.0360 ***	-0.0687 ***	-0.0267 **
Min production profit	-0.0299 ***	0.0170 **	0.0108
Max production profit	-0.0224	-0.0815 ***	-0.0224
10: Constant in natural gas demand function for America decreases by 25%			
Expected total welfare	-23.6465 ***	-1.0526 ***	-22.5939 ***
Expected avg welfare	-0.4729 ***	-0.0955 ***	-0.5834 ***
Min welfare	-0.4973 ***	-0.0045	-0.4973 ***
Max welfare	-0.1367 ***	-0.1367 ***	-0.3971 ***
Expected total production profit	-5.0966 ***	-1.2719 ***	-3.8247 ***
Expected avg production profit	-0.1019 ***	-0.1154 ***	-0.0981 ***
Min production profit	-0.0990 ***	-0.0034	-0.0654 ***
Max production profit	-0.4366 ***	-0.1031 ***	-0.4366 ***

Notes: Welfare is in billions of dollars per year.

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 21: Changes in welfare from base case under different demand shocks

	All firms	OPEC firms	Non-OPEC firms
11: Constant in natural gas demand function for Africa increases by 25%			
Expected total welfare	-28.6761 ***	-0.4337 **	-28.2424 ***
Expected avg welfare	-0.5735 ***	-0.1708 ***	-0.7260 ***
Min welfare	-0.5511 ***	-0.0120	-0.5511 ***
Max welfare	-0.1743 ***	-0.1743 ***	-0.7634 ***
Expected total production profit	-7.4033 ***	-2.5082 ***	-4.8951 ***
Expected avg production profit	-0.1481 ***	-0.2342 ***	-0.1250 ***
Min production profit	-0.1468 ***	0.0151 **	-0.0919 ***
Max production profit	-0.4899 ***	-0.2387 ***	-0.4899 ***
12: Constant in natural gas demand function for Asia & Oceania increases by 25%			
Expected total welfare	-2.8814	-1.4872 ***	-1.3942
Expected avg welfare	-0.0576	-0.0047	-0.0439
Min welfare	-0.0712	-0.0328 **	-0.0712
Max welfare	0.0186	0.0186	0.2986 ***
Expected total production profit	0.5336	0.7137 ***	-0.1801
Expected avg production profit	0.0107	0.0719 ***	-0.0053
Min production profit	0.0042	0.0014	0.0213 ***
Max production profit	-0.1007 ***	0.0788 ***	-0.1007 ***
13: Constant in natural gas demand function for Eurasia increases by 25%			
Expected total welfare	31.7725 ***	-0.7730 ***	32.5455 ***
Expected avg welfare	0.6354 ***	0.0602 ***	0.8264 ***
Min welfare	0.6654 ***	0.0046	0.4269 ***
Max welfare	0.1102 ***	0.1102 ***	1.0915 ***
Expected total production profit	8.8383 ***	2.7112 ***	6.1271 ***
Expected avg production profit	0.1768 ***	0.2535 ***	0.1565 ***
Min production profit	0.1640 ***	0.0073	0.1010 ***
Max production profit	0.5122 ***	0.2308 ***	0.5122 ***
14: Constant in natural gas demand function for Europe increases by 25%			
Expected total welfare	23.8823 ***	-1.3989 ***	25.2813 ***
Expected avg welfare	0.4776 ***	0.0033	0.6401 ***
Min welfare	0.7597 ***	-0.0165	0.4167 ***
Max welfare	0.1570 ***	0.1570 ***	0.7503 ***

Notes: Welfare is in billions of dollars per year.

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 21: (continued)

	All firms	OPEC firms	Non-OPEC firms
Expected total production profit	8.1555 ***	2.2814 ***	5.8741 ***
Expected avg production profit	0.1631 ***	0.2145 ***	0.1500 ***
Min production profit	0.1584 ***	0.1657 ***	0.1026 ***
Max production profit	0.4008 ***	0.1909 ***	0.4008 ***
15: Constant in natural gas demand function for Middle East increases by 25%			
Expected total welfare	27.7739 ***	-0.5895 ***	28.3634 ***
Expected avg welfare	0.5555 ***	0.0769 ***	0.7191 ***
Min welfare	0.7017 ***	0.0003	0.4614 ***
Max welfare	0.1216 ***	0.1216 ***	0.8581 ***
Expected total production profit	8.6291 ***	2.6620 ***	5.9670 ***
Expected avg production profit	0.1726 ***	0.2491 ***	0.1524 ***
Min production profit	0.1701 ***	0.0033	0.1043 ***
Max production profit	0.4296 ***	0.2235 ***	0.4296 ***
16: Constant in natural gas demand function for America increases by 25%			
Expected total welfare	-11.0360 ***	-1.4037 ***	-9.6323 ***
Expected avg welfare	-0.2207 ***	-0.1278 ***	-0.2488 ***
Min welfare	-0.0495	-0.0157	-0.0495
Max welfare	-0.0997 ***	-0.0997 ***	-0.3596 ***
Expected total production profit	-1.8953 ***	-0.7991 ***	-1.0962 ***
Expected avg production profit	-0.0379 ***	-0.0726 ***	-0.0281 ***
Min production profit	-0.0279 ***	0.0005	0.0031
Max production profit	-0.0946 ***	-0.0858 ***	-0.0946 ***

Notes: Welfare is in billions of dollars per year.

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 22: Change in action variables from base case under different demand shocks

	All firms	OPEC firms	Non-OPEC firms
1: Constant in both oil and all regional natural gas demand functions decreases by 10%			
Oil output (KBD)	0.0000	0.0000	0.0000
Natural gas output (MCFD)	0.0000	0.0000	0.0000
Exploration capex (2005 US$)	0.0000	0.0000	0.0000
Development capex (2005 US$)	0.0000	0.0000	0.0000
Acquisition capex (2005 US$)	0.0000	0.0000	0.0000
merging	0.0000		0.0000
acquiring another firm	0.0000		0.0000
being acquired by another firm	0.0000		0.0000
2: Constant in both oil and all regional natural gas demand functions decreases by 25%			
Oil output (KBD)	-8.1305 *	-8.7083	1.0403
Natural gas output (MCFD)	-77.2284 ***	72.5057 ***	-157.2015 ***
Exploration capex (2005 US$)	21.5318 ***	67.0313 ***	5.7374 ***
Development capex (2005 US$)	7.8390 ***	150.3711 ***	-39.9673 ***
Acquisition capex (2005 US$)	-28.5290 ***	6.8252 ***	-48.5463 ***
merging	0.0022 ***		0.0009 ***
acquiring another firm	-0.0052 ***		-0.0072 ***
being acquired by another firm	-0.0001 ***		-0.0002 ***
3: Constant in oil demand function decreases by 10%			
Oil output (KBD)	82.1576 ***	296.5715 ***	-3.0844 ***
Natural gas output (MCFD)	206.2013 ***	413.3183 ***	96.2620 ***
Exploration capex (2005 US$)	-28.3318 ***	8.5137 **	-37.8471 ***
Development capex (2005 US$)	-10.1119 ***	27.5214 ***	-3.3842 **
Acquisition capex (2005 US$)	20.1830 ***	-1.5900 **	25.2047 ***
merging	0.0017 ***		0.0003 *
acquiring another firm	0.0018 ***		0.0018 ***
being acquired by another firm	-0.0004 ***		-0.0005 ***
4: Constant in oil demand function decreases by 25%			
Oil output (KBD)	-101.4862 ***	-385.0607 ***	10.8893 ***
Natural gas output (MCFD)	-384.7906 ***	-506.6483 ***	-310.4886 ***
Exploration capex (2005 US$)	50.0754 ***	18.9622 ***	53.7672 ***
Development capex (2005 US$)	31.6544 ***	74.4952 ***	-21.2536 ***
Acquisition capex (2005 US$)	-48.8450 ***	5.8829 ***	-68.0596 ***
merging	0.0017 ***		0.0042 ***
acquiring another firm	-0.0104 ***		-0.0130 ***
being acquired by another firm	0.0002 ***		0.0003 ***

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 22: (continued)

	All firms	OPEC firms	Non-OPEC firms

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 23: Change in action variables from base case under different demand shocks

	All firms	OPEC firms	Non-OPEC firms
5: Constant in natural gas demand function for Africa decreases by 25%			
Oil output (KBD)	-11.5923 **	-50.5941 ***	15.9190 ***
Natural gas output (MCFD)	-121.1390 ***	3.7443	-190.0709 ***
Exploration capex (2005 US$)	37.5171 ***	90.5731 ***	18.5885 ***
Development capex (2005 US$)	33.4450 ***	227.6611 ***	-37.5898 ***
Acquisition capex (2005 US$)	-32.0468 ***	-5.6308 ***	-48.5510 ***
merging	0.0019 ***		0.0006 ***
acquiring another firm	-0.0064 ***		-0.0087 ***
being acquired by another firm	-0.0001 ***		-0.0002 ***
6: Constant in natural gas demand function for Asia & Oceania decreases by 25%			
Oil output (KBD)	-73.5851 ***	-287.3072 ***	19.1018 ***
Natural gas output (MCFD)	-316.3931 ***	-357.3788 ***	-291.5479 ***
Exploration capex (2005 US$)	52.8093 ***	63.1705 ***	44.8910 ***
Development capex (2005 US$)	36.4126 ***	178.0266 ***	-37.7549 ***
Acquisition capex (2005 US$)	-53.1977 ***	22.4111 ***	-87.7435 ***
merging	-0.0006 ***		-0.0008 ***
acquiring another firm	-0.0105 ***		-0.0134 ***
being acquired by another firm	0.0000		0.0000
7: Constant in natural gas demand function for Eurasia decreases by 25%			
Oil output (KBD)	-16.9295 ***	-89.6733 ***	20.3349 ***
Natural gas output (MCFD)	-150.1519 ***	-25.3606	-219.1128 ***
Exploration capex (2005 US$)	72.9374 ***	149.8730 ***	40.2263 ***
Development capex (2005 US$)	94.7557 ***	369.1910 ***	-21.4577 ***
Acquisition capex (2005 US$)	-52.7221 ***	8.1932 ***	-83.6117 ***
merging	0.0033 ***		0.0023 ***
acquiring another firm	-0.0110 ***		-0.0146 ***
being acquired by another firm	0.0001 ***		0.0001 ***
8: Constant in natural gas demand function for Europe decreases by 25%			
Oil output (KBD)	8.8036 *	2.3870	17.4238 ***
Natural gas output (MCFD)	-21.9342	50.9726 **	-67.5059 ***

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 23: (continued)

	All firms	OPEC firms	Non-OPEC firms
Exploration capex (2005 US$)	33.3350 ***	74.6032 ***	18.2566 ***
Development capex (2005 US$)	49.7610 ***	217.5295 ***	-13.4848 ***
Acquisition capex (2005 US$)	-32.4441 ***	2.6619 ***	-51.8346 ***
merging	0.0031 ***		0.0020 ***
acquiring another firm	-0.0082 ***		-0.0109 ***
being acquired by another firm	-0.0003 ***		-0.0004 ***
9: Constant in natural gas demand function for Middle East decreases by 25%			
Oil output (KBD)	-43.2296 ***	-150.4731 ***	5.9162 ***
Natural gas output (MCFD)	-170.7559 ***	-192.6955 ***	-157.0579 ***
Exploration capex (2005 US$)	18.0347 ***	12.7285 ***	19.6458 ***
Development capex (2005 US$)	5.8165 **	62.2753 ***	-22.4351 ***
Acquisition capex (2005 US$)	-26.2677 ***	-4.1197 ***	-36.8860 ***
merging	-0.0008 ***		-0.0010 ***
acquiring another firm	-0.0063 ***		-0.0081 ***
being acquired by another firm	-0.0002 ***		-0.0003 ***
10: Constant in natural gas demand function for America decreases by 25%			
Oil output (KBD)	18.1660 ***	46.2700 ***	0.0927
Natural gas output (MCFD)	-0.8103	49.8061 *	-20.6484 *
Exploration capex (2005 US$)	-3.2657	-9.9246 **	-2.6366
Development capex (2005 US$)	-9.1513 ***	-29.5558 ***	-6.9141 ***
Acquisition capex (2005 US$)	5.0688 **	-4.2434 ***	10.6125 ***
merging	-0.0001		-0.0001
acquiring another firm	-0.0005		-0.0006
being acquired by another firm	-0.0004 ***		-0.0005 ***

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 24: Change in action variables from base case under different demand shocks

	All firms	OPEC firms	Non-OPEC firms
11: Constant in natural gas demand function for Africa increases by 25%			
Oil output (KBD)	-72.2305 ***	-251.6068 ***	-2.7162 **
Natural gas output (MCFD)	-239.5435 ***	-350.8339 ***	-173.8898 ***
Exploration capex (2005 US$)	16.7712 ***	-27.4517 ***	29.1883 ***
Development capex (2005 US$)	-9.5219 ***	-54.9832 ***	-13.1405 ***
Acquisition capex (2005 US$)	-21.9896 ***	-5.7388 ***	-24.8546 ***
merging	-0.0006 ***		0.0012 ***

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 24: (continued)

	All firms	OPEC firms	Non-OPEC firms
acquiring another firm	-0.0036 ***		-0.0042 ***
being acquired by another firm	-0.0002 ***		-0.0002 ***
12: Constant in natural gas demand function for Asia & Oceania increases by 25%			
Oil output (KBD)	64.9104 ***	250.6490 ***	-9.1228 ***
Natural gas output (MCFD)	162.5812 ***	372.3980 ***	51.2257 ***
Exploration capex (2005 US$)	-13.1209 ***	27.8220 ***	-25.4763 ***
Development capex (2005 US$)	1.6441	60.1938 ***	-4.1233 **
Acquisition capex (2005 US$)	8.5469 ***	-0.7722	8.2928 ***
merging	0.0021 ***		0.0007 ***
acquiring another firm	0.0007 *		0.0004
being acquired by another firm	-0.0005 ***		-0.0006 ***
13: Constant in natural gas demand function for Eurasia increases by 25%			
Oil output (KBD)	19.7191 ***	101.0164 ***	-3.9400 ***
Natural gas output (MCFD)	62.7378 ***	221.7939 ***	-23.6316 *
Exploration capex (2005 US$)	18.3433 ***	76.7741 ***	-1.1142
Development capex (2005 US$)	32.1063 ***	176.0425 ***	-10.2545 ***
Acquisition capex (2005 US$)	-13.8587 ***	9.9068 ***	-30.3612 ***
merging	0.0047 ***		0.0041 ***
acquiring another firm	-0.0037 ***		-0.0053 ***
being acquired by another firm	-0.0005 ***		-0.0006 ***
14: Constant in natural gas demand function for Europe increases by 25%			
Oil output (KBD)	11.2099 **	4.0008	20.8729 ***
Natural gas output (MCFD)	-69.1456 ***	49.7184 **	-135.6223 ***
Exploration capex (2005 US$)	31.4228 ***	74.9485 ***	15.3935 ***
Development capex (2005 US$)	37.0114 ***	208.1787 ***	-28.0318 ***
Acquisition capex (2005 US$)	-28.5473 ***	4.9878 ***	-47.1271 ***
merging	0.0042 ***		0.0034 ***
acquiring another firm	-0.0078 ***		-0.0105 ***
being acquired by another firm	-0.0003 ***		-0.0004 ***
15: Constant in natural gas demand function for Middle East increases by 25%			
Oil output (KBD)	28.5774 ***	96.3143 ***	3.6803 ***
Natural gas output (MCFD)	77.3194 ***	223.3954 ***	-0.7438
Exploration capex (2005 US$)	22.2937 ***	76.4498 ***	1.6929
Development capex (2005 US$)	38.6565 ***	160.1666 ***	-1.8855
Acquisition capex (2005 US$)	-25.1840 ***	-1.6326 **	-40.0033 ***

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 24: (continued)

	All firms	OPEC firms	Non-OPEC firms
merging	0.0043 ***		0.0037 ***
acquiring another firm	-0.0043 ***		-0.0060 ***
being acquired by another firm	-0.0002 ***		-0.0002 ***
16: Constant in natural gas demand function for America increases by 25%			
Oil output (KBD)	-38.3872 ***	-149.0765 ***	12.8295 ***
Natural gas output (MCFD)	-193.5828 ***	-197.7524 ***	-188.1083 ***
Exploration capex (2005 US$)	15.3803 ***	12.8115 ***	16.3741 ***
Development capex (2005 US$)	2.0374	62.7609 ***	-27.0789 ***
Acquisition capex (2005 US$)	-27.0408 ***	0.0568	-39.5437 ***
merging	0.0010 ***		0.0013 ***
acquiring another firm	-0.0063 ***		-0.0081 ***
being acquired by another firm	-0.0004 ***		-0.0005 ***

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 25: Change in prices from base case under different demand shocks

1: Constant in both oil and all regional natural gas demand functions decreases by 10%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	0.0000
Asia & Oceania	0.0000
Eurasia	0.0273 **
Europe	0.0000
Middle East	0.0000
America	0.0000
2: Constant in both oil and all regional natural gas demand functions decreases by 25%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	0.0707 **
Asia & Oceania	0.0720
Eurasia	0.0436 ***
Europe	-0.1153 *
Middle East	-0.2227 **
America	-0.0907 *
3: Constant in oil demand function decreases by 10%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	-0.0601 *
Asia & Oceania	-0.2602
Eurasia	0.0189 *
Europe	-0.0768
Middle East	-0.0543
America	-0.0945 **
4: Constant in oil demand function decreases by 25%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	0.0884 **
Asia & Oceania	0.5536 **
Eurasia	-0.0267 *
Europe	0.0768
Middle East	-0.1467 *

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 25: (continued)

America	0.0416

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 26: Change in prices from base case under different demand shocks

5: Constant in natural gas demand function for Africa decreases by 25%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	0.0813 **
Asia & Oceania	0.0664
Eurasia	-0.0323 **
Europe	0.0064
Middle East	0.1412 *
America	-0.0945 **
6: Constant in natural gas demand function for Asia & Oceania decreases by 25%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	0.0813 **
Asia & Oceania	0.5259 **
Eurasia	-0.0360 **
Europe	0.0448
Middle East	-0.1630 *
America	-0.0113
7: Constant in natural gas demand function for Eurasia decreases by 25%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	0.0884 **
Asia & Oceania	0.2546
Eurasia	0.0441 ***
Europe	-0.1153 *
Middle East	-0.1032
America	-0.0945 **
8: Constant in natural gas demand function for Europe decreases by 25%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 26: (continued)

Africa	0.0141
Asia & Oceania	0.2104
Eurasia	-0.0180
Europe	-0.0960 *
Middle East	-0.0326
America	-0.0945 **
9: Constant in natural gas demand function for Middle East decreases by 25%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	-0.0071
Asia & Oceania	0.2214
Eurasia	-0.0139
Europe	-0.0704
Middle East	-0.0543
America	-0.0378
10: Constant in natural gas demand function for America decreases by 25%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	-0.0071
Asia & Oceania	0.0277
Eurasia	0.0146
Europe	-0.1409 **
Middle East	-0.1032
America	0.0151

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 27: Change in prices from base case under different demand shocks

11: Constant in natural gas demand function for Africa increases by 25%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	0.0141
Asia & Oceania	0.2768
Eurasia	-0.0026
Europe	-0.0512
Middle East	-0.0815

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 27: (continued)

America	0.0529
12: Constant in natural gas demand function for Asia & Oceania increases by 25%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	-0.0566 *
Asia & Oceania	-0.2104
Eurasia	0.0207 *
Europe	-0.0384
Middle East	0.1195
America	-0.0945 **
13: Constant in natural gas demand function for Eurasia increases by 25%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	0.0035
Asia & Oceania	-0.0055
Eurasia	-0.0619 ***
Europe	0.0029
Middle East	0.0163
America	-0.0945 *
14: Constant in natural gas demand function for Europe increases by 25%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	0.0106
Asia & Oceania	-0.0387
Eurasia	-0.0191
Europe	-0.0256
Middle East	-0.1467 *
America	-0.0907 *
15: Constant in natural gas demand function for Middle East increases by 25%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	0.0035
Asia & Oceania	0.0277
Eurasia	-0.0011
Europe	-0.0512

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 27: (continued)

Middle East	-0.1575 *
America	-0.0945 **
16: Constant in natural gas demand function for America increases by 25%	
Crude oil price, Brent (2005 US$/bbl)	0.0000
Regional natural gas price (2005 US$/mmbtu)	
Africa	0.0071
Asia & Oceania	0.2104
Eurasia	-0.0129
Europe	-0.0650
Middle East	-0.0815
America	-0.0076

Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

A Appendix A

Table A.1: Summary statistics for action variables

Variable	# Obs	Mean	Std. Dev.	Min	Max
Oil output (KBD)	1250	1089.934	1407.45	4	11035
Natural gas output (MCFD)	1250	2951.507	6528.964	0	55901.06
Exploration capex (million 2005 US$)	300	520.385	596.664	-13.232	2760.085
Development capex (million 2005 US$)	300	1743.55	2043.468	0	9045
Acquisition capex (million 2005 US$)	295	531.016	1720.282	-142.899	17625
Dummy for M&A at time t					
merging with another firm	1296	.005	.067	0	1
acquiring another firm	1296	.012	.11	0	1
being acquired by another firm	1296	.009	.095	0	1

Table A.2: Summary statistics for firm level state variables

Variable	# Obs	Mean	Std. Dev.	Min	Max
OPEC membership at time t (dummy)	1316	.211	.408	0	1
State ownership (in percentage)	1316	49.858	46.344	0	100
Oil reserves (million barrels)	1250	19473.12	45401.37	22	296501
Natural gas reserves (BCF)	1250	72399.95	177989.3	0	1320000

Table A.3: Summary statistics for prices of oil and natural gas

Variable	# Obs	Mean	Std. Dev.	Min	Max
Crude oil price, Brent (2005 US$/bbl)	25	35.6445	23.3058	13.6616	90.5464
Natural gas price, US (2005 US$/mmbtu)	25	3.6833	2.14151	1.5439	8.9157
Regional natural gas price (2005 US$/mmbtu)					
Africa	9	6.0782	2.2554	3.3171	9.6790
Asia & Oceania	9	12.1561	3.2825	8.2034	18.1676
Eurasia	9	1.3760	0.5569	0.7106	2.1370
Europe	9	10.2351	4.0633	5.1570	16.6824
Middle East	9	8.8214	3.4490	5.3768	15.1544
America	9	6.8508	2.2628	3.9221	10.7228

Table A.4: Estimated demand function for oil

	Dependent variable is: Oil quantity (KBD)	
	(1)	(2)
Crude oil price, Brent (2005 US$/bbl)	-274.6**	-495.3*
	(102.1)	(205.8)
World GDP per capita (2005 US$)	17.66*	36.69*
	(8.427)	(16.35)
World population (million people)	1.936	-19.40
	(9.522)	(18.09)
World electricity production from oil sources (kWh)	-1.11e-08	-4.02e-08
	(1.60e-08)	(2.89e-08)
Constant	-50081.5	-7019.2
	(27851.5)	(45755.7)
Instruments used:		
Average weekly earning		
for support activities in oil and gas extraction	Y	
for support activities in oil and gas extraction (lagged)		Y
First stage F-statistic	21.62	12.44
p-value of underidentification test	0.0035	0.0488
p-value of weak-instrument-robust inference tests	0.0092	0.0002
N	22	21
R^2	0.951	0.888
Root MSE	1810	2516

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.5: Estimated regional demand function for natural gas for Africa

	Dependent variable is: Regional natural gas consumption (MCFD)			
	(92-1*)	(92-3)	(92-4)	(91-33)
Natural gas regional price,(US$/mmbtu)	-2.213	-7.540	-14.97	-5.894
	(20.03)	(19.93)	(20.66)	(21.04)
Regional GDP (US$)	1.14e-09***	1.15e-09***	1.17e-09***	4.64e-10
	(1.14e-10)	(1.13e-10)	(1.15e-10)	(5.66e-10)
Regional population				0.00000456
				(0.00000355)
Constant	1688.1***	1706.9***	1732.9***	-1742.0
	(133.4)	(133.0)	(135.4)	(2713.4)
Instruments used:				
Lagged average weekly earnings (2005 US$)				
for oil and gas extraction	N	Y	Y	Y
for supporting activities in oil and gas	Y	Y	Y	N
Avg capital compensation (million 2005 US$)				
on other machinery and equipment	Y	N	Y	N
on transport equipment	Y	Y	N	N
on total non-residential investment	Y	Y	Y	Y
Avg industry rate of return on capital	Y	Y	Y	Y
Aggregate gas reserve (BCF)	Y	Y	Y	N
First stage F-statistic	17.61	74.20	2.60	5.38
p-value of underidentification test	0.1777	0.1746	0.2017	0.0478
p-value of weak-instrument-robust inference tests	0.3282	0.0001	0.0068	0.3675
p-value of Sargan-Hansen overidentification test	0.5603	0.2362	0.3701	0.3350
N	9	9	9	9
R^2	0.932	0.932	0.931	0.945
Root MSE	114.8	114.5	115.7	103.4

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.6: Estimated regional demand function for natural gas for Asia and Oceania

	Dependent variable is: Regional natural gas consumption (MCFD)				
	(91-39*)	(91-46)	(91-30)	(91-32)	(91-45)
Natural gas regional price,(US$/mmbtu)	-76.94	-30.18	-195.4	-22.75	-355.8
	(189.6)	(206.8)	(304.2)	(178.2)	(353.0)
Regional GDP (US$)	5.77e-10*	5.46e-10*	6.56e-10*	5.41e-10*	7.63e-10*
	(2.53e-10)	(2.52e-10)	(3.20e-10)	(2.41e-10)	(3.81e-10)
Regional population	0.0000135*	0.0000129*	0.0000151	0.0000129*	0.0000171
	(0.00000637)	(0.00000625)	(0.00000772)	(0.00000608)	(0.00000922)
Constant	-39914.4	-37989.0	-44790.6	-37683.5	-51393.2
	(20404.5)	(20014.5)	(24743.0)	(19447.4)	(29540.3)
Instruments used:					
Avg capital compensation (million 2005 US$)					
on other machinery and equipment	N	N	Y	N	N
on transport equipment	N	N	N	Y	N
on total non-residential investment	N	N	N	N	Y
Avg industry rate of return on capital	Y	Y	N	Y	N
Aggregate gas reserve (BCF)	Y	N	Y	Y	N
First stage F-statistic	2.67	2.38	0.71	1.79	1.31
p-value of underidentification test	0.0437	0.0275	0.2103	0.0906	0.0667
p-value of weak-instrument-robust inference tests	0.8001	0.8813	0.6690	0.2002	0.0939
p-value of Sargan-Hansen overidentification test	0.6459	NA	0.7563	0.2290	NA
N	9	9	9	9	9
R^2	0.984	0.985	0.979	0.985	0.970
Root MSE	337	323.8	381.5	322	459.8

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.7: Estimated regional demand function for natural gas for Eurasia

	Dependent variable is:	
	Regional natural gas consumption (MCFD)	
	(91-34*)	(91-29)
Natural gas regional price,(US$/mmbtu)	-5960.0***	-6039.3***
	(420.7)	(482.2)
Regional GDP (US$)	4.99e-09***	5.06e-09***
	(3.57e-10)	(4.07e-10)
Regional population	-0.00135***	-0.00135***
	(0.0000574)	(0.0000581)
Constant	408719.2***	409082.8***
	(16435.4)	(16636.3)
Instruments used:		
Lagged average weekly earnings (2005 US$)		
for supporting activities in oil and gas	Y	Y
for oil and gas extraction	Y	N
Avg capital compensation (million 2005 US$)		
on transport equipment	Y	Y
Avg industry rate of return on capital	N	Y
First stage F-statistic	13.23	1.76
p-value of underidentification test	0.0350	0.0826
p-value of weak-instrument-robust inference tests	0.0000	0.0000
p-value of Sargan-Hansen overidentification test	0.2582	0.0755
N	9	9
R^2	0.990	0.990
Root MSE	126.9	128.2

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.8: Estimated regional demand function for natural gas for Europe

	Dependent variable is:	
	Regional natural gas consumption (MCFD)	
	(91-21**)	(91-40)
Natural gas regional price,(US$/mmbtu)	-169.9	-344.7
	(165.2)	(185.5)
Regional GDP (US$)	5.15e-10***	6.11e-10***
	(1.44e-10)	(1.55e-10)
Regional population	-0.0000783	-0.0000361
	(0.0000679)	(0.0000730)
Constant	59235.9	34714.0
	(38457.1)	(41355.9)
Instruments used:		
Lagged average weekly earnings (2005 US$)		
for supporting activities in oil and gas	Y	N
for oil and gas extraction	Y	Y
Avg capital compensation (million 2005 US$)		
on total non-residential investment	N	Y
Avg industry rate of return on capital	Y	N
Aggregate gas reserve (BCF)	Y	N
First stage F-statistic	9.36	7.63
p-value of underidentification test	0.0738	0.0243
p-value of weak-instrument-robust inference tests	0.0000	0.0014
p-value of Sargan-Hansen overidentification test	0.0451	0.1406
N	9	9
R^2	0.833	0.817
Root MSE	331	346.8

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.9: Estimated regional demand function for natural gas for Middle East

	Dependent variable is: Regional natural gas consumption (MCFD)			
	(92-33*)	(92-38)	(92-40)	(92-45)
Natural gas regional price,(US$/mmbtu)	-12.14	11.55	-38.25	-37.77
	(47.81)	(49.62)	(50.26)	(50.23)
Regional population	0.000146***	0.000140***	0.000152***	0.000152***
	(0.0000126)	(0.0000130)	(0.0000132)	(0.0000132)
Constant	-18265.8***	-17372.0***	-19250.5***	-19232.7***
	(2027.4)	(2094.2)	(2118.4)	(2117.0)
Instruments used:				
Lagged average weekly earnings (2005 US$) for oil and gas extraction	Y	Y	Y	N
Avg capital compensation (million 2005 US$) on total non-residential investment	Y	N	Y	Y
Avg industry rate of return on capital	Y	Y	N	N
First stage F-statistic	49.67	61.88	57.38	103.23
p-value of underidentification test	0.0478	0.0228	0.0241	0.0063
p-value of weak-instrument-robust inference tests	0.0019	0.8	0.4334	0.4296
p-value of Sargan-Hansen overidentification test	0.0612	0.5473	0.3753	NA
N	9	9	9	9
R^2	0.990	0.990	0.989	0.989
Root MSE	177.1	179.7	180.7	180.6

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.10: Estimated regional demand function for natural gas for Americas

	Dependent variable is: Regional natural gas consumption (MCFD)				
	(92-33*)	(92-26)	(92-20)	(92-12)	(91-9)
Natural gas regional price,(US$/mmbtu)	-85.00	-67.54	-80.89	-74.39	-39.23
	(85.49)	(86.38)	(85.30)	(84.32)	(108.8)
Regional GDP (US$)	3.17e-10***	3.08e-10***	3.15e-10***	3.12e-10***	2.37e-10
	(6.64e-11)	(6.65e-11)	(6.63e-11)	(6.58e-11)	(3.12e-10)
Regional population					0.00000594
					(0.0000288)
Constant	26750.5***	26792.2***	26760.3***	26775.8***	22518.3
	(849.0)	(844.7)	(847.4)	(844.9)	(20904.6)
Instruments used:					
Lagged average weekly earnings (2005 US$)					
for supporting activities in oil and gas	N	N	N	Y	Y
for oil and gas extraction	Y	Y	Y	Y	N
Avg capital compensation (million 2005 US$)					
on other machinery and equipment	N	N	N	N	Y
on transport equipment	N	N	N	N	Y
on total non-residential investment	Y	N	Y	Y	Y
Avg industry rate of return on capital	Y	Y	Y	Y	Y
Aggregate gas reserve (BCF)	N	Y	Y	Y	N
First stage F-statistic	16.65	10.48	10.13	8.36	4.15
p-value of underidentification test	0.0369	0.0418	0.0750	0.1236	0.1305
p-value of weak-instrument-robust inference tests	0.0135	0.0001	0.0000	0.0000	0.0000
p-value of Sargan-Hansen overidentification test	0.1309	0.0426	0.0727	0.1195	0.0614
N	9	9	9	9	9
R^2	0.785	0.787	0.785	0.786	0.788
Root MSE	386.6	384.3	385.9	385	383

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.11: Estimation results for policy functions

	Dependent variable is:				
	Oil output	Natural gas output	Exploration capex	Development capex	Acquisition capex
Avg capital compensation (million 2005 US$)					
on transport equipment	0.761	4.030	2.246	7.716	10.85
	(2.655)	(7.666)	(5.110)	(14.23)	(21.58)
on other machinery and equipment	0.0934	0.491	0.177	0.520	0.546
	(0.172)	(0.496)	(0.331)	(0.921)	(1.397)
on total non-residential investment	0.131	0.549	0.219	0.162	0.127
	(0.208)	(0.602)	(0.401)	(1.117)	(1.694)
on other assets	0.0225	-0.148	-0.190	-0.810	0.0379
	(0.238)	(0.688)	(0.459)	(1.278)	(1.938)
Oil reserves (million Barrels)	0.102***	-0.0298*	0.000859	-0.00840	-0.0380
	(0.00475)	(0.0137)	(0.00914)	(0.0254)	(0.0386)
Natural gas reserves (BCF)	0.0111***	0.0996***	0.0205***	0.0490***	0.0184
	(0.00163)	(0.00470)	(0.00313)	(0.00872)	(0.0132)
Avg weekly earning (2005 US$)					
on oil and gas extraction	1.260	5.709	3.450	4.734	-6.329
	(2.339)	(6.753)	(4.501)	(12.53)	(19.01)
on supporting activities in oil and gas	0.874	4.311	3.434	7.274	-0.546
	(2.373)	(6.852)	(4.567)	(12.72)	(19.29)
Cumulative oil output (KBD)	0.0113*	-0.0779***	0.0101	0.0408	-0.00104
	(0.00474)	(0.0137)	(0.00912)	(0.0254)	(0.0385)
Cumulative gas output (MCFD)	-0.000100	0.0240***	-0.00340	-0.00831	0.00561
	(0.00167)	(0.00481)	(0.00321)	(0.00893)	(0.0135)

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.11: (continued)

	Dependent variable is:				
	Oil output	Natural gas output	Exploration capex	Development capex	Acquisition capex
Aggregate oil output (KBD)	-0.00424	-0.0315	-0.00614	0.000890	-0.0116
	(0.0252)	(0.0727)	(0.0485)	(0.135)	(0.205)
Aggregate gas output (MCFD)	-0.000200	0.00737	0.00407	0.00377	-0.0120
	(0.00625)	(0.0180)	(0.0120)	(0.0335)	(0.0508)
Cumulative					
Exploration capex (2005 US$)	0.0340	-0.0343	0.186***	0.0371	0.109
	(0.0183)	(0.0528)	(0.0352)	(0.0980)	(0.149)
Development capex (million 2005 US$)	-0.00169	0.0727***	-0.0547***	0.0487	-0.0420
	(0.00608)	(0.0176)	(0.0117)	(0.0326)	(0.0495)
acquisition capex (million 2005 US$)	0.00137	0.0315**	-0.0186*	0.0191	0.0314
	(0.00404)	(0.0117)	(0.00778)	(0.0217)	(0.0329)
Aggregate					
exploration capex (million 2005 US$)	0.0143	0.0732	-0.0168	0.0104	0.181
	(0.0733)	(0.212)	(0.141)	(0.393)	(0.596)
development capex (million 2005 US$)	0.00849	0.0224	0.00821	-0.0103	0.00210
	(0.0114)	(0.0329)	(0.0219)	(0.0611)	(0.0926)
acquisition capex (million 2005 US$)	-0.00572	-0.0300	-0.00720	0.00700	-0.0250
	(0.0109)	(0.0315)	(0.0210)	(0.0584)	(0.0886)
Aggregate oil reserves (million barrels)	-0.00480	-0.0198	-0.00717	-0.00923	-0.00395
	(0.00553)	(0.0160)	(0.0106)	(0.0296)	(0.0449)
Aggregate gas reserves (BCF)	0.000108	0.000539	0.000304	0.000799	0.000647
	(0.000218)	(0.000630)	(0.000420)	(0.00117)	(0.00177)

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.11: (continued)

	Dependent variable is:				
	Oil output	Natural gas output	Exploration capex	Development capex	Acquisition capex
World GDP per capita (2005 US$)	-1.234	-6.065	-3.163	-5.290	7.063
	(2.275)	(6.567)	(4.377)	(12.19)	(18.49)
Percentage of state ownership	1.158**	-7.148***	-3.318***	-6.515**	-2.339
	(0.426)	(1.230)	(0.820)	(2.283)	(3.463)
Lag dummy for merger	204.3	1617.3***	-145.3	-421.1	-234.9
	(161.0)	(464.7)	(309.7)	(862.5)	(1308.1)
Lag dummy for acquiring another firm	177.2	414.5	-119.1	-122.6	4035.3***
	(92.10)	(265.9)	(177.2)	(493.5)	(748.5)
Constant	9036.9	42039.7	17489.3	25295.1	-33943.4
	(14302.4)	(41292.6)	(27522.5)	(76637.4)	(116237.7)
N	252	252	252	252	252
R^2	0.933	0.950	0.617	0.748	0.255
Root MSE	206.94	597.46	398.22	1108.9	1681.8

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.12: Oil and natural gas production policy functions for OPEC firms

	Dependent variable is:	
	Oil output	Natural gas output
Avg capital compensation (million 2005 US$)		
on transport equipment	-4.065	-10.62
	(34.87)	(42.65)
on other machinery and equipment	-0.204	-0.834
	(1.402)	(1.715)
on total non-residential investment	-0.0981	-0.0783
	(0.304)	(0.372)
on other assets	0.459	1.415
	(2.110)	(2.581)
Oil reserves (million Barrels)	0.0176***	0.000415
	(0.00144)	(0.00176)
Natural gas reserves (BCF)	0.000524	0.00186***
	(0.000266)	(0.000326)
Avg weekly earning (2005 US$)		
on supporting activities in oil and gas	-0.586	-2.412
	(7.484)	(9.155)
Cumulative oil output (KBD)	0.0386***	-0.00133
	(0.00537)	(0.00657)
Cumulative gas output (MCFD)	0.0119***	0.103***
	(0.00346)	(0.00423)
Aggregate oil output (KBD)	0.0282	0.0148
	(0.122)	(0.149)
Aggregate gas output (MCFD)	-0.00801	-0.00309
	(0.0344)	(0.0421)
Aggregate oil reserves (million barrels)	0.000392	0.00662
	(0.0149)	(0.0182)
Aggregate gas reserves (BCF)	-0.0000213	-0.000514
	(0.00187)	(0.00229)
World GDP per capita (2005 US$)	2.316	1.402
	(7.867)	(9.624)
World population	-8.492	-8.726
	(38.08)	(46.58)

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.12: (continued)

	Dependent variable is:	
	Oil output	Natural gas output
Aggregate exploration capex (million 2005 US$)	-0.00534	0.00711
	(0.226)	(0.277)
Aggregate development capex (million 2005 US$)	0.0110	0.0203
	(0.101)	(0.123)
Aggregate acquisition capex (million 2005 US$)	0.00231	0.0196
	(0.0643)	(0.0787)
Constant	30697.6	36317.5
	(205966.5)	(251941.4)
N	173	173
R^2	0.900	0.863
Root MSE	725.51	887.45

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.13: Multinomial logit regression of decisions on merger and acquisitions for non-OPEC firms that are not 100% state-owned

	(1)	(2)	(3)	(4)	(5)
0: Base outcome					
1: Merge					
Oil reserves (million barrels)	-0.000969	-0.0184	-0.000678	-0.000692	-0.0241
	(0.00115)	(16.30)	(0.000923)	(0.000915)	(38.84)
Natural gas reserves (BCF)	0.000171	0.00623	0.000106	0.0000843	0.00625
	(0.000191)	(2.830)	(0.000155)	(0.000147)	(8.071)
Cumulative oil output (KBD)	0.000629	0.00901	0.000477	0.000389	0.0142
	(0.000749)	(15.23)	(0.000681)	(0.000558)	(20.92)
Cumulative natural gas output (MCFD)	-0.0000306	0.00313	-0.0000275	-0.0000449	
	(0.000259)	(10.78)	(0.000215)	(0.000151)	
Avg industry rate of return on capital	-95.99		-65.55		
	(64.26)		(41.02)		
Avg capital compensation (million 2005 US$)					
on other machinery and equipment		-0.964			-0.901
		(212.1)			(133.0)
on total non-residential investment	0.00105	0.00532		0.000208	0.00519
	(0.00119)	(4.109)		(0.000715)	(2.559)
Percentage of state ownership	-3.835	-5.975	-3.905	-3.359	-5.160
	(601.5)	(2604.6)	(627.0)	(464.2)	(1581.6)
Lag dummy for merger	-14.09	222.8	-15.09	-15.77	210.2
	(308979.2)	(1682718.4)	(213014.2)	(126734.6)	(1829812.3)
Lag dummy for acquiring another firm	-20.97	-7.690	-20.86	-19.15	-14.89
	(46820.3)	(399914.3)	(54990.4)	(37619.4)	(564250.7)
Cumulative exploration capex (million 2005 US$)	-0.00174	-0.0825	-0.00138	-0.000288	-0.0694

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.13: (continued)

	(1)	(2)	(3)	(4)	(5)
	(0.00175)	(42.33)	(0.00148)	(0.000939)	(22.40)
Cumulative development capex (million 2005 US$)	0.000363	0.0163	0.000314	0.0000469	0.0152
	(0.000457)	(4.922)	(0.000438)	(0.000327)	(4.906)
Cumulative acquisition capex (million 2005 US$)	-0.000364	-0.00801	-0.000204	-0.000237	-0.00782
	(0.000451)	(2.525)	(0.000413)	(0.000368)	(1.918)
Constant	4.092	1377.3	4.216	-4.408	1290.8
	(4.837)	(310162.1)	(4.736)	(2.483)	(177846.4)
2: Acquire another firm					
Oil reserves (million barrels)	-0.000999	-0.000756	-0.00102	-0.00108*	-0.000132
	(0.000571)	(0.000500)	(0.000570)	(0.000533)	(0.000384)
Natural gas reserves (BCF)	-0.000236*	-0.000483*	-0.000234*	-0.000224*	-0.0000764
	(0.000109)	(0.000197)	(0.000108)	(0.000101)	(0.0000697)
Cumulative oil output (KBD)	0.0000650	0.000553	0.0000465	-0.0000236	-0.000295
	(0.000293)	(0.000395)	(0.000282)	(0.000245)	(0.000218)
Cumulative natural gas output (MCFD)	-0.000350*	-0.000708**	-0.000343*	-0.000331*	
	(0.000151)	(0.000273)	(0.000146)	(0.000138)	
Avg industry rate of return on capital	-41.81		-37.44		
	(34.26)		(25.80)		
Avg capital compensation (million 2005 US$)					
on other machinery and equipment		-0.0109*			-0.00257
		(0.00513)			(0.00199)
on total non-residential investment	0.000173	-0.000193		-0.000366	-0.000747
	(0.000826)	(0.000640)		(0.000586)	(0.000513)
Percentage of state ownership	-0.0203	-0.0880	-0.0148	-0.0129	-0.00616
	(0.0534)	(0.0583)	(0.0459)	(0.0448)	(0.0382)

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.13: (continued)

	(1)	(2)	(3)	(4)	(5)
Lag dummy for merger	-23.17	-25.86	-22.41	-21.00	-26.71
	(139116.7)	(1075955.0)	(95709.8)	(52089.2)	(1071192.3)
Lag dummy for acquiring another firm	-22.49	-29.56	-21.74	-20.94	-27.23
	(53086.1)	(369831.2)	(37340.2)	(26521.0)	(503787.3)
Cumulative exploration capex (million 2005 US$)	0.00136	0.00127	0.00142	0.00162*	0.00170
	(0.000854)	(0.00101)	(0.000802)	(0.000792)	(0.000945)
Cumulative development capex (million 2005 US$)	0.0000737	0.000293	0.0000560	0.0000163	-0.000403
	(0.000291)	(0.000423)	(0.000276)	(0.000259)	(0.000305)
Cumulative acquisition capex (million 2005 US$)	0.000314*	0.000376*	0.000329*	0.000326*	0.000186
	(0.000146)	(0.000162)	(0.000133)	(0.000141)	(0.000103)
Constant	0.817	15.15	0.822	-2.402	2.439
	(2.967)	(8.012)	(2.964)	(1.901)	(3.743)
N	244	244	244	244	244
pseudo R^2	0.484	0.724	0.474	0.420	0.553

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.14: Logit regression of decisions on selling (being acquired) for non-OPEC firms that are not 100% state-owned

	(1)	(2)	(3)	(4)	(5)
Oil reserves (million barrels)	-0.000225	-0.000217	-0.000198	-0.000110	-0.000262
	(0.000239)	(0.000239)	(0.000239)	(0.000231)	(0.000173)
Natural gas reserves (BCF)	-0.0000643	-0.0000640	-0.0000706	-0.0000816	-0.0000576
	(0.0000702)	(0.0000704)	(0.0000733)	(0.0000761)	(0.0000644)
Cumulative oil output (KBD)	0.0000341	0.0000391	0.0000279	0.00000187	0.0000868
	(0.000193)	(0.000203)	(0.000204)	(0.000182)	(0.0000807)
Cumulative natural gas output (MCFD)	0.0000140	0.0000151	0.0000234	0.0000277	
	(0.0000566)	(0.0000587)	(0.0000597)	(0.0000543)	
Avg industry rate of return on capital	-41.99**		-31.07*		
	(15.79)		(12.13)		
Avg capital compensation (million 2005 US$)					
on other machinery and equipment		-0.00365*			-0.00367*
		(0.00159)			(0.00159)
on total non-residential investment	0.000364	-0.000117		-0.0000388	-0.000112
	(0.000256)	(0.000201)		(0.000146)	(0.000200)
Percentage of state ownership	-0.00456	-0.00743	-0.00152	-0.00413	-0.00904
	(0.0158)	(0.0155)	(0.0153)	(0.0145)	(0.0143)
Constant	0.947	3.846	0.908	-3.035***	3.909
	(1.546)	(2.757)	(1.507)	(0.703)	(2.747)
N	574	600	574	600	600
pseudo R^2	0.158	0.171	0.138	0.057	0.171

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.15: Estimated transition densities for oil and natural gas reserves and state ownership

	Dependent variable is:		
	Oil reserves (million barrels)	Natural gas reserves (BCF)	percentage of state ownership
Lag oil reserves (million barrels)	0.774***	-0.789***	-0.000521
	(0.0590)	(0.127)	(0.000424)
Lag natural gas reserves (BCF)	-0.00558	0.941***	0.000337**
	(0.0175)	(0.0378)	(0.000125)
Lag oil output (KBD)	1.785***	7.502***	0.00379
	(0.460)	(0.993)	(0.00331)
Lag natural gas output (MCFD)	-0.142	-0.585*	-0.00237*
	(0.129)	(0.278)	(0.000924)
Lag exploration capex (million 2005 US$)	-0.353	-1.077	-0.00263
	(0.304)	(0.655)	(0.00218)
Lag development capex (million 2005 US$)	-0.0513	0.0464	0.000445
	(0.113)	(0.244)	(0.000814)
Lag acquisition capex (million 2005 US$)	-0.0206	-0.0896	-0.000134
	(0.0492)	(0.106)	(0.000354)
Lag Percentage of state ownership	-4.954	-5.762	0.868***
	(3.254)	(7.024)	(0.0233)
Lag dummy for merger	4199.2***	13760.5***	-0.0118
	(995.3)	(2148.5)	(7.160)
Lag dummy for acquiring another firm	1147.0*	6993.3***	-2.989
	(540.3)	(1166.3)	(3.886)
Constant	319.1	30.32	1.372
	(184.2)	(397.6)	(1.307)
N	249	249	252

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.15: (continued)

	Dependent variable is:		
	Oil reserves (million barrels)	Natural gas reserves (BCF)	percentage of state ownership
R^2	0.913	0.968	0.920
Root MSE	1381.7	2982.8	9.9398

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.16: Estimated transition density for world population

	Dependent variable is: World population (million people)
Lag world population (million people)	0.994***
	(0.000149)
Constant	116.8***
	(0.890)
N	1203
R^2	1.000
Root MSE	2.8701

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.17: Estimated transition density for GDP per capita

	Dependent variable is: World GDP per capita (2005 US$)
Lag world GDP per capita (2005 US$)	1.003***
	(0.00411)
Constant	71.11**
	(26.59)
N	1203
R^2	0.980
Root MSE	95.064

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.18: Estimated transition densities for regional population

	Dependent variable is: Regional population					
	Africa	Asia and Oceania	Eurasia	Europe	Middle East	Americas
Lag regional population	1.022***	0.982***	0.815***	0.979***	1.014***	0.991***
	(0.000793)	(0.000535)	(0.0797)	(0.0192)	(0.00553)	(0.00132)
Constant	2377399.5**	102604406.2***	53407212.6*	14702775.6	1865626.2	18512826.5***
	(632438.5)	(1781063.3)	(22869701.1)	(11008355.2)	(927779.4)	(1082268.0)
N	24	24	24	24	24	24
R^2	1.000	1.000	0.826	0.992	0.999	1.000
Root MSE	5.2e5	8.0e5	9.8e5	1.6e6	7.6e5	4.9e5

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.19: Estimated transition densities for regional GDP

	Dependent variable is: Regional GDP (2005 US$)					
	Africa	Asia and Oceania	Eurasia	Europe	Middle East	Americas
Lag regional GDP	1.153***	1.151***	1.062***	1.005***	1.146***	1.041***
	(0.0439)	(0.0379)	(0.0862)	(0.0520)	(0.0597)	(0.0221)
Constant	-4.48941e+10	-6.11064e+11	5.56731e+10	5.59495e+11	-3.05928e+10	1.92957e+11
	(3.83697e+10)	(3.56436e+11)	(8.55987e+10)	(6.42472e+11)	(5.78489e+10)	(3.03131e+11)
N	24	24	24	24	24	24
R^2	0.969	0.977	0.873	0.944	0.944	0.990
Root MSE	9.2e10	6.6e11	2.5e11	1.1e12	1.5e11	5.1e11

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.20: Estimated transition density for avg industry rate of return on capital

	Dependent variable is: Avg industry rate of return on capital for mining and quarry
Lag avg industry rate of return on capital for mining and quarry	-1.005***
	(0.0295)
Lag aggregate oil reserves (million Barrels)	0.000000987***
	(2.86e-08)
Lag aggregate natural gas reserves (BCF)	-5.80e-08***
	(2.11e-09)
Lag avg capital compensation (million 2005 US$) on other machinery and equipment	-0.0000540***
	(0.00000144)
on total non-residential investment	0.00000925***
	(0.00000105)
Lag world road sector gasoline fuel consumption (kt of oil equivalent)	0.00000241***
	(0.000000115)
Lag world population (million people)	-0.000926***
	(0.0000281)
Lag world GDP per capita (2005 US$)	-0.0000776***
	(0.00000757)
Lag world electricity production (kWh) from natural gas sources	2.98e-13***
	(9.28e-15)
from oil sources	-1.03e-12***
	(2.45e-14)
Lag aggregate output of all firms Oil (KBD)	0.000000341
	(0.000000325)
Natural gas (MCFD)	-0.00000177***
	(0.000000121)
Constant	4.296***
	(0.0779)

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.20: (continued)

	Dependent variable is: Avg industry rate of return on capital for mining and quarry
N	750
R^2	0.970
Root MSE	0.00613

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.21: Estimated transition density for avg capital compensation on other machinery and equipment

	Dependent variable is: Avg capital compensation on other machinery and equipment
Lag avg industry rate of return on capital for mining and quarry	1365.0***
	(348.4)
Lag aggregate oil reserves (million barrels)	0.0196***
	(0.000348)
Lag aggregate natural gas reserves (BCF)	-0.00105***
	(0.0000287)
Lag avg capital compensation (million 2005 US$) on other machinery and equipment	0.0439*
	(0.0188)
on total non-residential investment	-0.0155
	(0.0129)
Lag world road sector gasoline fuel consumption (kt of oil equivalent)	0.0479***
	(0.00123)
Lag world population (million people)	-12.85***
	(0.288)
Lag world GDP per capita (2005 US$)	-4.037***

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.21: (continued)

	Dependent variable is: Avg capital compensation on other machinery and equipment
	(0.103)
Lag world electricity production (kWh)	
from natural gas sources	5.33e-09***
	(1.26e-10)
from oil sources	-3.48e-09***
	(2.70e-10)
Lag aggregate output of all firms	
Oil (KBD)	-0.100***
	(0.00431)
Natural gas (MCFD)	-0.00540***
	(0.00152)
Constant	48009.7***
	(1023.5)
N	799
R^2	0.984
Root MSE	84.461

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.22: Estimated transition density for avg capital compensation on total non-residential investment

	Dependent variable is: Avg capital compensation on total non-residential investment
Lag avg industry rate of return on capital	
for mining and quarry	-9793.8***
	(1027.7)
Lag aggregate oil reserves (million barrels)	0.0238***
	(0.00103)

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.22: (continued)

	Dependent variable is: Avg capital compensation on total non-residential investment
Lag aggregate natural gas reserves (BCF)	-0.00133***
	(0.0000847)
Lag avg capital compensation (million 2005 US$)	
on other machinery and equipment	-1.862***
	(0.0554)
on total non-residential investment	0.288***
	(0.0382)
Lag world road sector	
gasoline fuel consumption (kt of oil equivalent)	0.0913***
	(0.00363)
Lag world population (million people)	-18.10***
	(0.850)
Lag world GDP per capita (2005 US$)	2.459***
	(0.303)
Lag world electricity production (kWh)	
from natural gas sources	2.57e-09***
	(3.73e-10)
from oil sources	-2.77e-08***
	(7.96e-10)
Lag aggregate output of all firms	
Oil (KBD)	-0.221***
	(0.0127)
Natural gas (MCFD)	-0.0479***
	(0.00447)
Constant	52944.6***
	(3018.8)
N	799
R^2	0.988
Root MSE	249.12

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.23: Estimated transition density for world road sector gasoline fuel consumption

	Dependent variable is: World road sector gasoline fuel consumption (kt of oil equivalent)
Lag avg industry rate of return on capital for mining and quarry	-67174.8***
	(7757.0)
Lag aggregate oil reserves (million barrels)	0.0681***
	(0.00774)
Lag aggregate natural gas reserves (BCF)	-0.00510***
	(0.000639)
Lag avg capital compensation (million 2005 US$) on other machinery and equipment	-3.795***
	(0.418)
on total non-residential investment	1.360***
	(0.288)
Lag world road sector gasoline fuel consumption (kt of oil equivalent)	0.656***
	(0.0274)
Lag world population (million people)	125.3***
	(6.413)
Lag world GDP per capita (2005 US$)	-40.56***
	(2.286)
Lag world electricity production (kWh) from natural gas sources	-5.56e-08***
	(2.81e-09)
from oil sources	-8.99e-08***
	(6.01e-09)
Lag aggregate output of all firms Oil (KBD)	2.995***
	(0.0960)
Natural gas (MCFD)	0.378***
	(0.0338)
Constant	-226225.2***
	(22785.8)
N	799
R^2	0.998
Root MSE	1880.3

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.23: (continued)

	Dependent variable is:
	World road sector gasoline fuel consumption (kt of oil equivalent)

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.24: Estimated transition density for world motor vehicles

	Dependent variable is: World motor vehicles (per 1,000 people)
Lag aggregate oil reserves (million barrels)	-0.000708***
	(0.000154)
Lag avg capital compensation (million 2005 US$) on total non-residential investment	0.0283**
	(0.0102)
Lag world road sector gasoline fuel consumption (kt of oil equivalent)	0.000419*
	(0.000200)
Lag world motor vehicles (per 1,000 people)	1.232***
	(0.341)
Lag world electricity production (kWh) from natural gas sources	-1.25e-10***
	(3.35e-11)
from oil sources	7.30e-11
	(1.53e-10)
Lag aggregate oil output of all firms (KBD)	0.0144***
	(0.00355)
Constant	-375.4
	(384.0)
N	432
R^2	0.847
Root MSE	4.2212

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.25: Estimated transition density for world electricity production from natural gas sources

	Dependent variable is: World electricity production from natural gas sources (kWh)
Lag avg industry rate of return on capital for mining and quarry	-1.00546e+12***
	(5.49455e+10)
Lag aggregate oil reserves (million barrels)	667398.1***
	(54844.7)
Lag aggregate natural gas reserves (BCF)	-1946.8
	(4529.8)
Lag avg capital compensation (million 2005 US$) on other machinery and equipment	-137198427.2***
	(2959959.6)
on total non-residential investment	-38581285.1***
	(2040441.5)
Lag world road sector gasoline fuel consumption (kt of oil equivalent)	-958016.6***
	(193818.5)
Lag world population (million people)	1.23760e+09***
	(45427800.1)
Lag world GDP per capita (2005 US$)	447240369.9***
	(16189014.5)
Lag world electricity production (kWh) from natural gas sources	-0.391***
	(0.0199)
from oil sources	-2.678***
	(0.0425)
Lag aggregate output of all firms Oil (KBD)	27159110.5***
	(680113.6)
Natural gas (MCFD)	11117179.1***
	(239226.4)
Constant	-6.26490e+12***
	(1.61399e+11)

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.25: (continued)

	Dependent variable is: World electricity production from natural gas sources (kWh)
N	799
R^2	1.000
Root MSE	1.3e10

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.26: Estimated transition density for world electricity production from oil sources

	Dependent variable is: World electricity production from oil sources (kWh)
Lag avg industry rate of return on capital for mining and quarry	-1.29705e+12***
	(4.12199e+10)
Lag aggregate oil reserves (million barrels)	-554911.8***
	(41144.2)
Lag aggregate natural gas reserves (BCF)	48747.4***
	(3398.2)
Lag avg capital compensation (million 2005 US$) on other machinery and equipment	21049440.2***
	(2220549.6)
on total non-residential investment	22978949.9***
	(1530730.9)
Lag world road sector gasoline fuel consumption (kt of oil equivalent)	-116019.6
	(145401.9)
Lag world population (million people)	-70654784.0*
	(34079749.4)
Lag world GDP per capita (2005 US$)	127831765.8***
	(12144932.3)

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A.26: (continued)

	Dependent variable is: World electricity production from oil sources (kWh)
Lag world electricity production (kWh)	
from natural gas sources	-0.186***
	(0.0150)
from oil sources	-0.0661*
	(0.0319)
Lag aggregate output of all firms	
Oil (KBD)	10355770.0***
	(510218.5)
Natural gas (MCFD)	-555873.4**
	(179466.7)
Constant	1.18372e+12***
	(1.21081e+11)
Observations	799
R^2	0.988
Root MSE	1.0e10

Notes: Standard errors in parentheses. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

B Appendix B

Table B.1: Simulated welfare under different OPEC membership scenarios

	All firms	OPEC firms	Non-OPEC firms
OPEC membership case where all firms are members of OPEC			
Expected total welfare	270.1678 ***	270.1678 ***	
	(6.7568)	(6.7568)	
	[174.2428] ***	[218.4090] ***	
Expected avg. welfare	5.4034 ***	5.4034 ***	
	(0.1351)	(0.1351)	
	[3.4848] ***	[0.8285] ***	
Min welfare	0.3736 *	0.0406	
	(0.1767)	(0.2217)	
	[-0.1048] ***	[-0.2134] ***	
Max welfare	7.1631 ***	7.1631 ***	
	(0.1818)	(0.1818)	
	[0.2955] ***	[0.2955] ***	
Expected total production profit	12.1931	12.1931	
	(7.4862)	(7.4862)	
	[-3.2619] ***	[5.6799] ***	
Expected avg. production profit	0.2439	0.2439	
	(0.1497)	(0.1497)	
	[-0.06523] ***	[-0.3412] ***	
Min production profit	-0.1819	0.0343	
	(0.1387)	(0.0241)	
	[-0.0229] ***	[0.0308] ***	
Max production profit	1.7471 ***	1.7471 ***	
	(0.2137)	(0.2137)	
	[-3.0392] ***	[0.2155] ***	
OPEC membership case where no firms are members of OPEC			
Expected total welfare	-49.0923		-49.0923
	(4.7371)		(4.7371)
	[-145.0173] ***		[-93.2585] ***

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.1: (continued)

	All firms	OPEC firms	Non-OPEC firms
Expected avg. welfare	-0.9818 (0.0947) [-2.9003] ***		-0.9818 (0.0947) [-2.1224] ***
Min welfare	-4.0841 *** (0.2544) [-3.5009] ***		-4.0841 *** (0.2544) [-3.5009] ***
Max welfare	0.3367 ** (0.1149) [-6.531] ***		0.3367 ** (0.1149) [-1.9185] ***
Expected total production profit	19.9983 *** (4.9572) [4.543269] ***		19.9983 *** (4.9572) [11.0565] ***
Expected avg. production profit	0.4000 *** (0.0991) [0.0909] ***		0.4000 *** (0.0991) [0.1700] ***
Min production profit	-0.2345 ** (0.0807) [-0.07551] ***		-0.2345 ** (0.0807) [-0.0584] ***
Max production profit	4.9745 *** (0.3095) [0.18808] ***		4.9745 *** (0.3095) [0.1881] ***

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.2: Summary statistics for action variables under OPEC membership case where all firms are in OPEC

Variable	All firms Mean	All firms Std. Dev.	OPEC firms Mean	OPEC firms Std. Dev.	Non-OPEC firms Mean	Non-OPEC firms Std. Dev.
Oil output (KBD)	1184.251 ***	1848.469 ***	1184.251 ***	1848.469 ***		
	(76.719)	(112.644)	(76.719)	(112.644)		
	[-319.263] ***		[-1328.602] ***			
Natural gas output (MCFD)	2149.403 ***	2736.644 ***	2149.403 ***	2736.644 ***		
	(170.173)	(137.917)	(170.173)	(137.917)		
	[-1725.358] ***		[-1187.065] ***			
Exploration capex (million 2005 US$)	539.517 ***	821.757 ***	539.517 ***	821.757 ***		
	(15.170)	(10.010)	(15.170)	(10.010)		
	[-139.605] ***		[-587.410] ***			
Development capex (million 2005 US$)	1437.323 ***	2329.497 ***	1437.323 ***	2329.497 ***		
	(15.285)	(14.515)	(15.285)	(14.515)		
	[-394.919] ***		[-1653.703] ***			
Acquisition capex (million 2005 US$)	518.889 ***	995.540 ***	518.889 ***	995.540 ***		
	(4.349)	(7.196)	(4.349)	(7.196)		
	[-257.944] ***		[19.226] ***			
Dummy for M&A at time t						
merging						
acquiring another firm						
being acquired by another firm						

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.3: Summary statistics for action variables under OPEC membership case where no firm is in OPEC

Variable	All firms Mean	All firms Std. Dev.	OPEC firms Mean	OPEC firms Std. Dev.	Non-OPEC firms Mean	Non-OPEC firms Std. Dev.
Oil output (KBD)	1591.114 ***	1394.283 ***			1591.114 ***	1394.283 ***
	(9.734)	(9.189)			(9.734)	(9.189)
	[87.600] ***				[562.272] ***	
Natural gas output (MCFD)	6050.010 ***	12019.865 ***			6050.010 ***	12019.865 ***
	(141.847)	(270.714)			(141.847)	(270.714)
	[2175.249] ***				[1914.401] ***	
Exploration capex (million 2005 US$)	756.760 ***	928.850 ***			756.760 ***	928.850 ***
	(22.747)	(9.461)			(22.747)	(9.461)
	[77.638] ***				[289.805] ***	
Development capex (million 2005 US$)	1943.474 ***	2676.307 ***			1943.474 ***	2676.307 ***
	(19.641)	(25.023)			(19.641)	(25.023)
	[111.233] ***				[710.946] ***	
Acquisition capex (million 2005 US$)	748.891 ***	1321.944 ***			748.891 ***	1321.944 ***
	(23.880)	(31.422)			(23.880)	(31.422)
	[-27.942] ***				[-159.977]	
Dummy for M&A at time t						
merging	0.206 ***	0.405 ***			0.206 ***	0.405 ***
	(0.001)	(0.001)			(0.001)	(0.001)
	[0.032] ***				[-0.019] ***	
acquiring another firm	0.038	0.188			0.038	0.188
	(0.004)	(0.010)			(0.004)	(0.010)
	[-0.010] ***				[-0.024] ***	
being acquired by another firm	0.003 ***	0.042 ***			0.003 ***	0.042 ***
	(0.000)	(0.002)			(0.000)	(0.002)
	[0.001] ***				[0.000] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.4: Summary statistics of prices under different OPEC membership case simulations

	All firms in OPEC		No firm in OPEC	
	Mean	Std. Dev.	Mean	Std. Dev.
Oil price	70.5065 ***	0.0000	68.5801 ***	3.3235 **
	(0.0000)	(0.0000)	(1.0281)	(1.4666)
	[0.0000]		[-1.9264] ***	
Regional Natural Gas Prices				
1	8.6187 ***	2.5972 ***	8.4031 ***	2.6917 ***
	(0.0016)	(0.0010)	(0.1398)	(0.0473)
	[0.0884] ***		[-0.1272]	
2	12.3607 ***	5.1672 ***	12.3496 ***	5.1197 ***
	(0.4978)	(0.0768)	(0.2886)	(0.0615)
	[0.2048]		[0.1937]	
3	2.1370 ***	0.0000	1.8907 ***	0.5125 ***
	(0.0000)	(0.0000)	(0.0202)	(0.0337)
	[0.0494] ***		[-0.1969] ***	
4	6.2903 ***	2.6924 ***	6.2199 ***	2.4652 ***
	(0.0851)	(0.1557)	(0.0975)	(0.2126)
	[0.0128]		[-0.0576]	
5	11.0641 ***	4.8129 ***	10.9826 ***	4.7701 ***
	(0.1036)	(0.0525)	(0.1259)	(0.0497)
	[-0.0598]		[-0.1412]	
6	9.9747 ***	1.8324 **	9.3589 ***	2.8773 ***
	(0.2892)	(0.7083)	(0.1230)	(0.0421)
	[0.2909] *		[-0.3249] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.5: Simulated welfare under privatization simulation

	All firms	OPEC firms	Non-OPEC firms
State ownership=0%			
Expected total welfare	-14.9834	34.0231 ***	-49.0065
	(3.8871)	(0.7347)	(3.7075)
	[-110.9084] ***	[-17.7357] ***	[-93.1726] ***
Expected avg. welfare	-0.2997	3.0095 ***	-1.2685
	(0.0777)	(0.0876)	(0.0996)
	[-2.2182] ***	[-1.5654] ***	[-2.4091] ***
Min welfare	-3.9407 ***	0.0534	-3.9407 ***
	(0.2975)	(0.1322)	(0.2975)
	[-3.3575] ***	[-0.2005] ***	[-3.3575] ***
Max welfare	5.4247 ***	5.4247 ***	0.0000 ***
	(0.1027)	(0.1027)	(0.0000)
	[-1.4430] ***	[-1.4430] ***	[-2.2552] ***
Expected total production profit	12.9474 *	5.8543 ***	7.0931 *
	(5.0821)	(1.5594)	(3.5600)
	[-2.5077] ***	[-0.6589] ***	[-1.8487] ***
Expected avg. production profit	0.2589 *	0.5267 ***	0.1822 *
	(0.1016)	(0.1446)	(0.0911)
	[-0.0502] ***	[-0.0583] ***	[-0.0478] ***
Min production profit	-0.1833	0.0380	-0.1632 **
	(0.1042)	(0.0589)	(0.0613)
	[-0.0243] **	[0.0345] ***	[0.0128] *
Max production profit	3.8704 ***	1.4748 ***	3.8704 ***
	(0.2716)	(0.1416)	(0.2716)
	[-0.9160] ***	[-0.0568] ***	[-0.9160] ***
State ownership=50%			
Expected total welfare	179.1246 ***	43.2350 ***	135.8895 ***
	(34.2941)	(0.7160)	(33.9365)
	[83.1996] ***	[-8.5238] ***	[91.7234] ***
Expected avg. welfare	3.5825 ***	3.8226 ***	3.5115 ***
	(0.6859)	(0.0989)	(0.8603)
	[1.6640] ***	[-0.7523] ***	[2.3709] ***

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.5: (continued)

	All firms	OPEC firms	Non-OPEC firms
Min welfare	-0.4041 *	0.1021	0.0000 ***
	(0.1771)	(0.2629)	(0.0000)
	[0.1791] ***	[-0.1519] ***	[0.5832] ***
Max welfare	7.1132 ***	6.2588 ***	6.8341 ***
	(0.6903)	(0.1253)	(1.3956)
	[0.2455] ***	[-0.6089] ***	[4.5789] ***
Expected total production profit	13.2961 *	6.0544 **	7.2417
	(6.1035)	(1.8900)	(4.2451)
	[-2.1589] ***	[-0.4588] ***	[-1.7001] ***
Expected avg. production profit	0.2659 *	0.5441 **	0.1861
	(0.1221)	(0.1754)	(0.1086)
	[-0.0432] ***	[-0.0410] ***	[-0.0438] ***
Min production profit	-0.1735	0.0535	-0.1498 *
	(0.1242)	(0.0573)	(0.0727)
	[-0.0145]	[0.0501] ***	[0.0262] ***
Max production profit	3.8908 ***	1.4966 ***	3.8908 ***
	(0.3326)	(0.1706)	(0.3326)
	[-0.8956] ***	[-0.0350] **	[-0.8956] ***
State ownership=100%			
Expected total welfare	86.9764 ***	53.5460 ***	33.4304 ***
	(6.9632)	(0.7008)	(6.7011)
	[-8.9486] ***	[1.7872] ***	[-10.7358] ***
Expected avg. welfare	1.7395 ***	4.7335 ***	0.8605 ***
	(0.1393)	(0.1049)	(0.1699)
	[-0.1790] ***	[0.1586] ***	[-0.2801] ***
Min welfare	-1.5699 ***	0.3285 *	-1.5699 ***
	(0.3042)	(0.1664)	(0.3042)
	[-0.9867] ***	[0.0746] ***	[-0.9867] ***
Max welfare	7.9559 ***	7.1472 ***	6.9296 ***
	(0.5469)	(0.1236)	(1.2289)
	[1.0882] ***	[0.2795] ***	[4.6744] ***
Expected total production profit	16.3824 *	7.0084 ***	9.3740
	(7.8353)	(1.9124)	(5.9785)

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.5: (continued)

	All firms	OPEC firms	Non-OPEC firms
	[0.9274]	[0.4952] ***	[0.4322]
Expected avg. production profit	0.3276 *	0.6295 ***	0.2407
	(0.1567)	(0.1781)	(0.1531)
	[0.0185]	[0.0444] ***	[0.0108]
Min production profit	-0.2177	0.0287	-0.2306 *
	(0.1386)	(0.0952)	(0.0968)
	[-0.0587] ***	[0.0252] ***	[-0.0545] ***
Max production profit	5.7366 ***	1.5800 ***	5.7366 ***
	(0.4316)	(0.1699)	(0.4316)
	[0.9502] ***	[0.0483] ***	[0.9502] ***

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.6: Summary statistics for action variables under privatization simulation, state ownership=0%

Variable	All firms Mean	All firms Std. Dev.	OPEC firms Mean	OPEC firms Std. Dev.	Non-OPEC firms Mean	Non-OPEC firms Std. Dev.
Oil output (KBD)	1480.764 ***	1811.517 ***	2508.261 ***	2556.795 ***	966.667 ***	920.859 ***
	(42.451)	(72.271)	(152.779)	(111.120)	(10.623)	(6.886)
	[-22.750] ***		[-4.591]		[-62.175] ***	
Natural gas output (MCFD)	3794.304 ***	6763.797 ***	3343.780 ***	3380.998 ***	4028.746 ***	7922.188 ***
	(140.143)	(80.244)	(216.522)	(135.344)	(102.594)	(92.338)
	[-80.457] ***		[7.313]		[-106.863] ***	
Exploration capex (million 2005 US$)	774.302 ***	920.186 ***	1283.488 ***	1132.386 ***	517.506 ***	655.147 ***
	(22.977)	(6.942)	(35.806)	(7.943)	(24.790)	(12.130)
	[95.180] ***		[156.561] ***		[50.551] ***	
Development capex (million 2005 US$)	2000.955 ***	2619.089 ***	3398.077 ***	3444.101 ***	1292.582 ***	1685.053 ***
	(25.204)	(21.374)	(86.309)	(27.767)	(10.018)	(14.619)
	[168.714] ***		[307.052] ***		[60.054] ***	
Acquisition capex (million 2005 US$)	790.251 ***	1384.900 ***	500.296 ***	957.443 ***	937.024 ***	1533.313 ***
	(20.888)	(27.762)	(6.543)	(7.247)	(29.171)	(33.583)
	[13.418] ***		[0.633]		[28.156] ***	
Dummy for M&A at time t						
merging	0.184 ***	0.388 ***			0.238 ***	0.426 ***
	(0.002)	(0.001)			(0.002)	(0.001)
	[0.010] ***				[0.013] ***	
acquiring another firm	0.049 ***	0.214 ***			0.063 ***	0.242 ***
	(0.004)	(0.009)			(0.005)	(0.010)
	[0.001] **				[0.001] **	
being acquired by another firm	0.002 ***	0.031 ***			0.003 ***	0.035 ***
	(0.000)	(0.003)			(0.000)	(0.003)
	[0.000] ***				[-0.001] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.7: Summary statistics for action variables under privatization simulation, state ownership=50%

Variable	All firms Mean	All firms Std. Dev.	OPEC firms Mean	OPEC firms Std. Dev.	Non-OPEC firms Mean	Non-OPEC firms Std. Dev.
Oil output (KBD)	1529.886 ***	1807.016 ***	2519.743 ***	2560.410 ***	1034.957 ***	932.162 ***
	(45.150)	(73.694)	(159.922)	(114.468)	(11.863)	(5.963)
	[26.372] ***		[6.890]		[6.116] ***	
Natural gas output (MCFD)	3643.499 ***	6775.191 ***	3351.417 ***	3387.241 ***	3798.554 ***	7942.234 ***
	(147.998)	(97.711)	(231.756)	(142.735)	(109.786)	(111.114)
	[-231.261] ***		[14.949]		[-337.054] ***	
Exploration capex (million 2005 US$)	679.795 ***	914.642 ***	1198.343 ***	1140.275 ***	418.459 ***	629.422 ***
	(22.273)	(9.090)	(42.020)	(10.460)	(22.720)	(12.631)
	[0.673]		[71.416] ***		[-48.497] ***	
Development capex (million 2005 US$)	1823.099 ***	2607.692 ***	3233.190 ***	3442.293 ***	1108.777 ***	1653.170 ***
	(27.790)	(24.779)	(100.334)	(31.922)	(10.713)	(17.785)
	[-9.142] ***		[142.165] ***		[-123.751] ***	
Acquisition capex (million 2005 US$)	778.838 ***	1367.536 ***	518.004 ***	969.475 ***	910.827 ***	1509.045 ***
	(21.138)	(28.614)	(7.193)	(7.848)	(29.858)	(35.201)
	[2.006]		[18.342] ***		[1.959]	
Dummy for M&A at time t						
merging	0.186 ***	0.389 ***			0.240 ***	0.427 ***
	(0.002)	(0.002)			(0.002)	(0.001)
	[0.012] ***				[0.015] ***	
acquiring another firm	0.045 ***	0.204 ***			0.058 ***	0.231 ***
	(0.004)	(0.010)			(0.005)	(0.011)
	[-0.004] ***				[-0.005] ***	
being acquired by another firm	0.002 ***	0.033 ***			0.003 ***	0.038 ***
	(0.000)	(0.003)			(0.000)	(0.003)
	[0.000] ***				[0.000] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.8: Summary statistics for action variables under privatization simulation, state ownership=100%

Variable	All firms Mean	All firms Std. Dev.	OPEC firms Mean	OPEC firms Std. Dev.	Non-OPEC firms Mean	Non-OPEC firms Std. Dev.
Oil output (KBD)	1277.102 ***	1607.551 ***	2506.446 ***	2562.565 ***	921.456 ***	927.692 ***
	(34.283)	(68.732)	(173.519)	(124.900)	(7.248)	(5.112)
	[-226.412] ***		[-6.406]		[-107.386] ***	
Natural gas output (MCFD)	2908.851 ***	7193.418 ***	3344.629 ***	3388.196 ***	2785.548 ***	7971.533 ***
	(132.504)	(51.894)	(242.926)	(150.649)	(106.055)	(38.711)
	[-965.909] ***		[8.161]		[-1350.061] ***	
Exploration capex (million 2005 US$)	463.331 ***	818.690 ***	1110.778 ***	1145.667 ***	274.361 ***	571.124 ***
	(18.291)	(7.652)	(38.790)	(9.899)	(18.284)	(11.077)
	[-215.791] ***		[-16.149] ***		[-192.595] ***	
Development capex (million 2005 US$)	1300.863 ***	2336.158 ***	3068.421 ***	3439.687 ***	783.276 ***	1561.930 ***
	(12.991)	(14.356)	(91.708)	(28.009)	(9.716)	(13.670)
	[-531.378] ***		[-22.604] **		[-449.253] ***	
Acquisition capex (million 2005 US$)	518.889 ***	995.540 ***	502.398 ***	958.651 ***	523.638 ***	1003.360 ***
	(4.349)	(7.196)	(6.335)	(7.545)	(5.286)	(8.725)
	[-257.944] ***		[2.736] ***		[-385.230] ***	
Dummy for M&A at time t						
merging						
acquiring another firm						
being acquired by another firm						

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.9: Summary statistics of prices under different privatization simulations

	State ownership=0%		State ownership=50%		State ownership=100%	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Crude oil price, Brent (2005 US$/bbl)	70.5065 ***	0.0000	70.5065 ***	0.0000	70.5065 ***	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	[0.0000]		[0.0000]		[0.0000]	
Regional natural gas price (2005 US$/mmbtu)						
Africa	4.3810 ***	2.5995 ***	8.6187 ***	2.5972 ***	8.6187 ***	2.5972 ***
	(0.0045)	(0.0028)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	[-4.1494] ***		[0.0884] ***		[0.0884] ***	
Asia & Oceania	11.5248 ***	5.1455 ***	18.1455 ***	0.0542	18.1565 ***	0.0271
	(0.0050)	(0.0032)	(0.0139)	(0.0340)	(0.0140)	(0.0340)
	[-0.6311] ***		[5.9896] ***		[6.0007] ***	
Eurasia	1.8993 ***	0.5823 ***	2.1370 ***	0.0000	2.1370 ***	0.0000 ***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	[-0.1883] ***		[0.0494] ***		[0.0494] ***	
Europe	6.1687 ***	2.4781 ***	9.9657 ***	5.6626 ***	9.9080 ***	5.6298
	(0.0491)	(0.1202)	(0.1208)	(0.0663)	(0.1327)	(0.0602)
	[-0.1089] **		[3.6881] ***		[3.6305] ***	
Middle East	11.1510 ***	4.7384 ***	11.2434 ***	4.6723 ***	11.0641 ***	4.8129 ***
	(0.0928)	(0.0578)	(0.1018)	(0.0571)	(0.1035)	(0.0525)
	[0.0272]		[0.1195]		[-0.0598]	
America	5.2180 ***	2.8581 ***	10.7228 ***	0.0000	10.7228 ***	0.0000
	(0.0821)	(0.0386)	(0.0031)	(0.0076)	(0.0006)	(0.0016)
	[-4.4658] ***		[1.0390] ***		[1.0390] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.10: Simulated welfare under merger ban simulation

	All firms	OPEC firms	Non-OPEC firms
Expected total welfare	18.9190 **	52.2269 ***	-33.3079
	(6.7798)	(0.8197)	(6.4824)
	[-77.0060] ***	[0.4680] **	[-77.4741] ***
Expected avg. welfare	0.3784 **	4.6165 ***	-0.8631
	(0.1356)	(0.1100)	(0.1703)
	[-1.5401] ***	[0.0416] **	[-2.0037] ***
Min welfare	-3.1742 ***	0.3315 *	-3.1742 ***
	(0.4628)	(0.1590)	(0.4628)
	[-2.5911] ***	[0.0775] ***	[-2.5911] ***
Max welfare	6.8454 ***	6.8454 ***	0.6879 ***
	(0.1179)	(0.1179)	(0.1970)
	[-0.0223]	[-0.0223]	[-1.5673] ***
Expected total production profit	16.9094 *	7.0129 ***	9.8966
	(6.8033)	(1.7411)	(5.1192)
	[1.4544] **	[0.4996] ***	[0.9548] **
Expected avg. production profit	0.3382 *	0.6296 ***	0.2542
	(0.1361)	(0.1628)	(0.1311)
	[0.0291] **	[0.0445] ***	[0.0242] **
Min production profit	-0.1989	0.0411	-0.2203 *
	(0.1191)	(0.0958)	(0.0870)
	[-0.0399] ***	[0.0376] ***	[-0.0442] ***
Max production profit	5.6996 ***	1.5783 ***	5.6996 ***
	(0.3761)	(0.1598)	(0.3761)
	[0.9132] ***	[0.0466] ***	[0.9132] ***

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.11: Summary statistics for action variables under merger ban simulation

Variable	All firms Mean	All firms Std. Dev.	OPEC firms Mean	OPEC firms Std. Dev.	Non-OPEC firms Mean	Non-OPEC firms Std. Dev.
Oil output (KBD)	1239.325 ***	1622.868 ***	2515.537 ***	2563.195 ***	860.261 ***	912.892 ***
	(35.918)	(71.614)	(182.262)	(130.604)	(6.598)	(4.488)
	[-264.189] ***		[2.684]		[-168.581] ***	
Natural gas output (MCFD)	3218.133 ***	7242.421 ***	3336.401 ***	3382.530 ***	3186.917 ***	8053.853 ***
	(151.032)	(46.548)	(258.097)	(159.179)	(123.285)	(30.491)
	[-656.627] ***		[-0.067]		[-948.692] ***	
Exploration capex (million 2005 US$)	556.724 ***	828.551 ***	1124.486 ***	1138.962 ***	386.878 ***	615.891 ***
	(20.294)	(10.842)	(32.993)	(10.268)	(22.227)	(16.717)
	[-122.398] ***		[-2.441]		[-80.077] ***	
Development capex (million 2005 US$)	1493.886 ***	2341.788 ***	3087.996 ***	3428.477 ***	1014.668 ***	1624.358 ***
	(12.614)	(16.175)	(79.779)	(28.434)	(14.196)	(11.340)
	[-338.356] ***		[-3.030]		[-217.860] ***	
Acquisition capex (million 2005 US$)	717.101 ***	1325.745 ***	506.257 ***	958.135 ***	780.398 ***	1409.664 ***
	(14.607)	(21.422)	(5.731)	(7.548)	(18.118)	(24.692)
	[-59.731] ***		[6.594] ***		[-128.470] ***	
Dummy for M&A at time t						
merging						
acquiring another firm	0.064 ***	0.244 ***			0.083 ***	0.275 ***
	(0.003)	(0.006)			(0.004)	(0.007)
	[0.016] ***				[0.021] ***	
being acquired by another firm	0.009 ***	0.086 ***			0.011 ***	0.098 ***
	(0.001)	(0.004)			(0.001)	(0.004)
	[0.006] ***				[0.008] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.12: Summary statistics for price under merger ban simulation

Price	Mean	Std. Dev.
Crude oil price, Brent (2005 US$/bbl)	70.5065 ***	0.0000
	(0.0000)	(0.0000)
		[0.0000]
Regional natural gas price (2005 US$/mmbtu)		
Africa	8.3359 ***	2.7552 ***
	(0.1279)	(0.0676)
		[-0.1944] **
Asia & Oceania	11.6853 ***	5.1673 ***
	(0.1167)	(0.0134)
		[-0.4705] ***
Eurasia	2.0887 ***	0.1184 **
	(0.0153)	(0.0376)
		[0.0011]
Europe	6.1303 ***	2.3725 ***
	(0.0546)	(0.1331)
		[-0.1473] **
Middle East	11.1076 ***	4.7350 ***
	(0.0920)	(0.0559)
		[-0.0163]
America	9.6725 ***	2.5728 ***
	(0.0561)	(0.1375)
		[-0.0113]

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.13: Simulated welfare under various demand shock scenarios

	All firms	OPEC firms	Non-OPEC firms
1: Constant in both oil and all regional natural gas demand functions decreases by 10%			
Expected total welfare	97.0319 ***	51.7606 ***	45.2713 *
	(22.2609)	(0.6193)	(22.0183)
	[1.1069]	[0.0018]	[1.1051]
Expected avg. welfare	1.9406 ***	4.5751 ***	1.1691 *
	(0.4452)	(0.0998)	(0.5618)
	[0.0221]	[0.0002]	[0.0286]
Min welfare	-0.5716	0.2542	-0.5716 *
	(0.4472)	(0.1450)	(0.2886)
	[0.0116]	[0.0002]	[0.0116]
Max welfare	6.8677 ***	6.8677 ***	2.3518 **
	(0.1239)	(0.1239)	(0.7281)
	[0.0001]	[0.0001]	[0.0966]
Expected total production profit	15.4550 **	6.5132 ***	8.9418 *
	(5.9638)	(1.8050)	(4.1953)
	[0.0000]	[0.0000]	[0.0000]
Expected avg. production profit	0.3091 **	0.5851 ***	0.2299 *
	(0.1193)	(0.1681)	(0.1073)
	[0.0000]	[0.0000]	[0.0000]
Min production profit	-0.1590	0.0035	-0.1761 *
	(0.1147)	(0.0927)	(0.0753)
	[0.0000]	[0.0000]	[0.0000]
Max production profit	4.7864 ***	1.5316 ***	4.7864 ***
	(0.3602)	(0.1634)	(0.3602)
	[0.0000]	[0.0000]	[0.0000]
2: Constant in both oil and all regional natural gas demand functions decreases by 25%			
Expected total welfare	124.7961 ***	50.9048 ***	73.8913 **
	(23.6707)	(0.7640)	(23.3517)
	[28.8711] ***	[-0.8540] ***	[29.7252] ***
Expected avg. welfare	2.4959 ***	4.6277 ***	1.8946 **
	(0.4734)	(0.1028)	(0.5962)
	[0.5774] ***	[0.0528] ***	[0.7541] ***

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.13: (continued)

	All firms	OPEC firms	Non-OPEC firms
Min welfare	0.1523	0.3654 **	0.0000
	(0.4608)	(0.1154)	(0.2879)
	[0.7355] ***	[0.1114] ***	[0.5832] ***
Max welfare	6.9902 ***	6.9902 ***	3.2538 ***
	(0.1315)	(0.1315)	(0.7613)
	[0.1226] ***	[0.1226] ***	[0.9986] ***
Expected total production profit	23.1714 ***	8.7005 ***	14.4709 **
	(6.2945)	(1.8616)	(4.4665)
	[7.7164] ***	[2.1873] ***	[5.5291] ***
Expected avg. production profit	0.4634 ***	0.7910 ***	0.3710 **
	(0.1259)	(0.1730)	(0.1142)
	[0.1543] ***	[0.2059] ***	[0.1411] ***
Min production profit	0.0132	0.1798 *	-0.0026
	(0.1217)	(0.0842)	(0.0763)
	[0.1722] ***	[0.1763] ***	[0.1735] ***
Max production profit	5.1478 ***	1.7152 ***	5.1478 ***
	(0.3767)	(0.1674)	(0.3767)
	[0.3614] ***	[0.1835] ***	[0.3614] ***
3: Constant in oil demand function decreases by 10%			
Expected total welfare	104.2445 ***	51.0819 ***	53.1627 *
	(22.1713)	(0.7723)	(21.7413)
	[8.3196] ***	[-0.6769] ***	[8.9965] ***
Expected avg. welfare	2.0849 ***	4.6438 ***	1.3631 *
	(0.4434)	(0.1022)	(0.5554)
	[0.1664] ***	[0.0689] ***	[0.2226] ***
Min welfare	-0.5293	0.2185	-0.5293
	(0.4356)	(0.1310)	(0.2748)
	[0.0539]	[-0.0354] **	[0.0539]
Max welfare	6.8703 ***	6.8703 ***	2.7994 ***
	(0.1197)	(0.1197)	(0.7224)
	[0.0027]	[0.0027]	[0.5442] ***
Expected total production profit	17.2805 **	7.6302 ***	9.6503 *
	(5.7343)	(1.7048)	(4.0665)

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.13: (continued)

	All firms	OPEC firms	Non-OPEC firms
	[1.8255] ***	[1.1170] ***	[0.7085] *
Expected avg. production profit	0.3456 **	0.6937 ***	0.2474 *
	(0.1147)	(0.1582)	(0.1040)
	[0.0365] ***	[0.1086] ***	[0.0175] *
Min production profit	-0.1377	0.0066	-0.1537 *
	(0.1109)	(0.0814)	(0.0742)
	[0.0213] **	[0.0031]	[0.0224] ***
Max production profit	4.7320 ***	1.6579 ***	4.7320 ***
	(0.3507)	(0.1545)	(0.3507)
	[-0.0544] *	[0.1262] ***	[-0.0544] *
4: Constant in oil demand function decreases by 25%			
Expected total welfare	94.3887 ***	51.7581 ***	42.6305 *
	(21.8374)	(0.8125)	(21.3465)
	[-1.5363]	[-0.0007]	[-1.5356]
Expected avg. welfare	1.8878 ***	4.4442 ***	1.1089 *
	(0.4367)	(0.1032)	(0.5451)
	[-0.0307]	[-0.1307] ***	[-0.0317]
Min welfare	-0.2528	0.0097	-0.3754
	(0.4164)	(0.1223)	(0.2576)
	[0.3304] ***	[-0.2442] ***	[0.2078] ***
Max welfare	6.8701 ***	6.8701 ***	1.9496 **
	(0.1173)	(0.1173)	(0.7424)
	[0.0024]	[0.0024]	[-0.3056] ***
Expected total production profit	15.7221 **	5.8703 ***	9.8518 *
	(5.6275)	(1.6722)	(3.9976)
	[0.2671]	[-0.6429] ***	[0.9100] **
Expected avg. production profit	0.3144 **	0.5200 ***	0.2538 *
	(0.1125)	(0.1549)	(0.1023)
	[0.0053]	[-0.0650] ***	[0.0238] **
Min production profit	-0.1586	0.0629	-0.1965 **
	(0.1068)	(0.0810)	(0.0664)
	[0.0004]	[0.0594] ***	[-0.0205] ***
Max production profit	4.6894 ***	1.4291 ***	4.6894 ***

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.13: (continued)

	All firms	OPEC firms	Non-OPEC firms
	(0.3438)	(0.1510)	(0.3438)
	[-0.0970] ***	[-0.1026] ***	[-0.0970] ***

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.14: Simulated welfare under various demand shock scenarios

	All firms	OPEC firms	Non-OPEC firms
5: Constant in natural gas demand function for Africa decreases by 25%			
Expected total welfare	140.0372 ***	51.4286 ***	88.6086 ***
	(22.0010)	(0.7425)	(21.6607)
	[44.1122] ***	[-0.3302] *	[44.4424] ***
Expected avg. welfare	2.8007 ***	4.6753 ***	2.2720 ***
	(0.4400)	(0.0993)	(0.5527)
	[0.8822] ***	[0.1004] ***	[1.1314] ***
Min welfare	0.4925	0.3450 **	0.0000
	(0.4347)	(0.1104)	(0.2694)
	[1.0757] ***	[0.0910] ***	[0.5832] ***
Max welfare	7.1088 ***	7.1088 ***	3.7124 ***
	(0.1261)	(0.1261)	(0.7149)
	[0.2411] ***	[0.2411] ***	[1.4572] ***
Expected total production profit	28.1645 ***	9.9584 ***	18.2061 ***
	(5.8478)	(1.7466)	(4.1315)
	[12.7094] ***	[3.4451] ***	[9.2643] ***
Expected avg. production profit	0.5633 ***	0.9053 ***	0.4668 ***
	(0.1170)	(0.1622)	(0.1057)
	[0.2542] ***	[0.3202] ***	[0.2369] ***
Min production profit	0.0986	0.1596 *	0.0000
	(0.1119)	(0.0790)	(0.0716)
	[0.2576] ***	[0.1561] ***	[0.1761] ***
Max production profit	5.4625 ***	1.8150 ***	5.4625 ***
	(0.3675)	(0.1566)	(0.3675)

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.14: (continued)

	All firms	OPEC firms	Non-OPEC firms
	[0.6761] ***	[0.2834] ***	[0.6761] ***
6: Constant in natural gas demand function for Asia & Oceania decreases by 25%			
Expected total welfare	110.3564 ***	50.8820 ***	59.4745 **
	(22.9115)	(0.6810)	(22.6028)
	[14.4314] ***	[-0.8769] ***	[15.3083] ***
Expected avg. welfare	2.2071 ***	4.4956 ***	1.5357 **
	(0.4582)	(0.0999)	(0.5769)
	[0.2886] ***	[-0.0793] ***	[0.3952] ***
Min welfare	0.0606	0.4147 **	-0.1974
	(0.4645)	(0.1433)	(0.2733)
	[0.6438] ***	[0.1608] ***	[0.3858] ***
Max welfare	6.9033 ***	6.9033 ***	2.4762 **
	(0.1323)	(0.1323)	(0.7529)
	[0.0356] *	[0.0356] *	[0.2210] ***
Expected total production profit	21.4271 ***	7.6530 ***	13.7741 **
	(6.3714)	(1.8663)	(4.5415)
	[5.9721] ***	[1.1398] ***	[4.8323] ***
Expected avg. production profit	0.4285 ***	0.6885 ***	0.3539 **
	(0.1274)	(0.1731)	(0.1162)
	[0.1194] ***	[0.1034] ***	[0.1239] ***
Min production profit	-0.0217	0.0698	-0.0957
	(0.1222)	(0.0966)	(0.0723)
	[0.1373] ***	[0.0663] ***	[0.0804] ***
Max production profit	5.1887 ***	1.5891 ***	5.1887 ***
	(0.3953)	(0.1663)	(0.3953)
	[0.4023] ***	[0.0574] ***	[0.4023] ***
7: Constant in natural gas demand function for Eurasia decreases by 25%			
Expected total welfare	163.9592 ***	51.7417 ***	112.2174 ***
	(19.4331)	(0.6695)	(19.1395)
	[68.0342] ***	[-0.0171]	[68.0513] ***
Expected avg. welfare	3.2792 ***	4.7038 ***	2.8774 ***
	(0.3887)	(0.0900)	(0.4884)

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.14: (continued)

	All firms	OPEC firms	Non-OPEC firms
	[1.3607] ***	[0.1289] ***	[1.7368] ***
Min welfare	0.7936 *	0.7358 ***	0.0000
	(0.3945)	(0.1120)	(0.2408)
	[1.3768] ***	[0.4819] ***	[0.5832] ***
Max welfare	7.2713 ***	7.2713 ***	4.4896 ***
	(0.1120)	(0.1120)	(0.6353)
	[0.4037] ***	[0.4037] ***	[2.2345] ***
Expected total production profit	35.9354 ***	12.0481 ***	23.8873 ***
	(5.1719)	(1.5148)	(3.6992)
	[20.4804] ***	[5.5349] ***	[14.9455] ***
Expected avg. production profit	0.7187 ***	1.0953 ***	0.6125 ***
	(0.1034)	(0.1406)	(0.0947)
	[0.4096] ***	[0.5102] ***	[0.3826] ***
Min production profit	0.2206 *	0.4829 ***	0.0000
	(0.0999)	(0.0703)	(0.0646)
	[0.3796] ***	[0.4794] ***	[0.1761] ***
Max production profit	5.7453 ***	1.9904 ***	5.7453 ***
	(0.3204)	(0.1361)	(0.3204)
	[0.9590] ***	[0.4588] ***	[0.9590] ***
8: Constant in natural gas demand function for Europe decreases by 25%			
Expected total welfare	122.7287 ***	50.5643 ***	72.1644 ***
	(20.0693)	(0.7316)	(19.6869)
	[26.8037] ***	[-1.1945] ***	[27.9982] ***
Expected avg. welfare	2.4546 ***	4.5968 ***	1.8504 ***
	(0.4014)	(0.0907)	(0.5027)
	[0.5361] ***	[0.0219]	[0.7098] ***
Min welfare	0.1476	0.2999 *	-0.1667
	(0.3900)	(0.1395)	(0.2368)
	[0.7308] ***	[0.0459] ***	[0.4165] ***
Max welfare	7.0252 ***	7.0252 ***	3.1184 ***
	(0.1105)	(0.1105)	(0.6646)
	[0.1575] ***	[0.1575] ***	[0.8633] ***
Expected total production profit	24.5868 ***	9.0514 ***	15.5354 ***

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.14: (continued)

	All firms	OPEC firms	Non-OPEC firms
	(5.2569)	(1.5484)	(3.7472)
	[9.1318] ***	[2.5382] ***	[6.5936] ***
Expected avg. production profit	0.4917 ***	0.8229 ***	0.3983 ***
	(0.1051)	(0.1437)	(0.0959)
	[0.1826] ***	[0.2378] ***	[0.1684] ***
Min production profit	0.0204	0.0157	-0.0695
	(0.1001)	(0.0830)	(0.0627)
	[0.1794] ***	[0.0122] *	[0.1066] ***
Max production profit	5.4194 ***	1.7388 ***	5.4194 ***
	(0.3246)	(0.1397)	(0.3246)
	[0.6330] ***	[0.2072] ***	[0.6330] ***
9: Constant in natural gas demand function for Middle East decreases by 25%			
Expected total welfare	86.7069 ***	50.4364 ***	36.2705
	(23.3751)	(0.6335)	(23.0962)
	[-9.2181] ***	[-1.3224] ***	[-7.8957] ***
Expected avg. welfare	1.7341 ***	4.4545 ***	0.9366
	(0.4675)	(0.1037)	(0.5889)
	[-0.1844] ***	[-0.1204] ***	[-0.2039] ***
Min welfare	-0.5859	0.2475 *	-0.5859 *
	(0.4407)	(0.1196)	(0.2683)
	[-0.0027]	[-0.0064]	[-0.0027]
Max welfare	6.8045 ***	6.8045 ***	2.0693 **
	(0.1251)	(0.1251)	(0.7661)
	[-0.0631] ***	[-0.0631] ***	[-0.1859] **
Expected total production profit	13.6560 *	5.7538 **	7.9022
	(6.2210)	(1.8571)	(4.3981)
	[-1.7990] ***	[-0.7594] ***	[-1.0396] **
Expected avg. production profit	0.2731 *	0.5164 **	0.2032
	(0.1244)	(0.1727)	(0.1125)
	[-0.0360] ***	[-0.0687] ***	[-0.0267] **
Min production profit	-0.1889	0.0205	-0.1653 *
	(0.1196)	(0.0866)	(0.0761)
	[-0.0299] ***	[0.0170] **	[0.0108]

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.14: (continued)

	All firms	OPEC firms	Non-OPEC firms
Max production profit	4.7640 ***	1.4501 ***	4.7640 ***
	(0.3779)	(0.1678)	(0.3779)
	[-0.0224]	[-0.0815] ***	[-0.0224]
10: Constant in natural gas demand function for America decreases by 25%			
Expected total welfare	72.2785 ***	50.7063 ***	21.5722
	(21.5629)	(0.7560)	(21.3291)
	[-23.6465] ***	[-1.0526] ***	[-22.5939] ***
Expected avg. welfare	1.4456 ***	4.4794 ***	0.5571
	(0.4313)	(0.0947)	(0.5442)
	[-0.4729] ***	[-0.0955] ***	[-0.5834] ***
Min welfare	-1.0805 *	0.2494	-1.0805 ***
	(0.4411)	(0.1347)	(0.2645)
	[-0.4973] ***	[-0.0045]	[-0.4973] ***
Max welfare	6.7310 ***	6.7310 ***	1.8581 **
	(0.1261)	(0.1261)	(0.7063)
	[-0.1367] ***	[-0.1367] ***	[-0.3971] ***
Expected total production profit	10.3584	5.2413 **	5.1171
	(5.9374)	(1.7642)	(4.2167)
	[-5.0966] ***	[-1.2719] ***	[-3.8247] ***
Expected avg. production profit	0.2072	0.4697 **	0.1318
	(0.1187)	(0.1641)	(0.1079)
	[-0.1019] ***	[-0.1154] ***	[-0.0981] ***
Min production profit	-0.2580 *	0.0001	-0.2415 ***
	(0.1144)	(0.0766)	(0.0718)
	[-0.0990] ***	[-0.0034]	[-0.0654] ***
Max production profit	4.3497 ***	1.4285 ***	4.3497 ***
	(0.3686)	(0.1581)	(0.3686)
	[-0.4366] ***	[-0.1031] ***	[-0.4366] ***

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.15: Simulated welfare under various demand shock scenarios

	All firms	OPEC firms	Non-OPEC firms
11: Constant in natural gas demand function for Africa increases by 25%			
Expected total welfare	67.2488 **	51.3251 ***	15.9237
	(22.3605)	(0.7175)	(22.0617)
	[-28.6761] ***	[-0.4337] **	[-28.2424] ***
Expected avg. welfare	1.3450 **	4.4041 ***	0.4146
	(0.4472)	(0.1032)	(0.5636)
	[-0.5735] ***	[-0.1708] ***	[-0.7260] ***
Min welfare	-1.1343 *	0.2419	-1.1343 ***
	(0.4587)	(0.1402)	(0.3089)
	[-0.5511] ***	[-0.0120]	[-0.5511] ***
Max welfare	6.6934 ***	6.6934 ***	1.4917 *
	(0.1227)	(0.1227)	(0.7107)
	[-0.1743] ***	[-0.1743] ***	[-0.7634] ***
Expected total production profit	8.0517	4.0050 *	4.0467
	(5.9079)	(1.8004)	(4.1534)
	[-7.4033] ***	[-2.5082] ***	[-4.8951] ***
Expected avg. production profit	0.1610	0.3508 *	0.1049
	(0.1182)	(0.1678)	(0.1062)
	[-0.1481] ***	[-0.2342] ***	[-0.1250] ***
Min production profit	-0.3058 **	0.0185	-0.2679 ***
	(0.1148)	(0.0807)	(0.0777)
	[-0.1468] ***	[0.0151] **	[-0.0919] ***
Max production profit	4.2965 ***	1.2929 ***	4.2965 ***
	(0.3643)	(0.1639)	(0.3643)
	[-0.4899] ***	[-0.2387] ***	[-0.4899] ***
12: Constant in natural gas demand function for Asia & Oceania increases by 25%			
Expected total welfare	93.0436 ***	50.2716 ***	42.7720
	(22.5782)	(0.6965)	(22.2505)
	[-2.8814]	[-1.4872] ***	[-1.3942]
Expected avg. welfare	1.8609 ***	4.5701 ***	1.0967
	(0.4516)	(0.0953)	(0.5680)
	[-0.0576]	[-0.0047]	[-0.0439]

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.15: (continued)

	All firms	OPEC firms	Non-OPEC firms
Min welfare	-0.6544	0.2211	-0.6544 *
	(0.4686)	(0.1175)	(0.2932)
	[-0.0712]	[-0.0328] **	[-0.0712]
Max welfare	6.8863 ***	6.8863 ***	2.5538 ***
	(0.1264)	(0.1264)	(0.7112)
	[0.0186]	[0.0186]	[0.2986] ***
Expected total production profit	15.9886 **	7.2269 ***	8.7617 *
	(5.9739)	(1.7073)	(4.3075)
	[0.5336]	[0.7137] ***	[-0.1801]
Expected avg. production profit	0.3198 **	0.6570 ***	0.2247 *
	(0.1195)	(0.1584)	(0.1102)
	[0.0107]	[0.0719] ***	[-0.0053]
Min production profit	-0.1548	0.0049	-0.1548 *
	(0.1174)	(0.0842)	(0.0774)
	[0.0042]	[0.0014]	[0.0213] ***
Max production profit	4.6857 ***	1.6105 ***	4.6857 ***
	(0.3688)	(0.1508)	(0.3688)
	[-0.1007] ***	[0.0788] ***	[-0.1007] ***
13: Constant in natural gas demand function for Eurasia increases by 25%			
Expected total welfare	127.6974 ***	50.9858 ***	76.7116 ***
	(20.3991)	(0.7732)	(20.0702)
	[31.7725] ***	[-0.7730] ***	[32.5455] ***
Expected avg. welfare	2.5539 ***	4.6351 ***	1.9670 ***
	(0.4080)	(0.0991)	(0.5117)
	[0.6354] ***	[0.0602] ***	[0.8264] ***
Min welfare	0.0822	0.2586 *	-0.1563
	(0.3727)	(0.1230)	(0.2275)
	[0.6654] ***	[0.0046]	[0.4269] ***
Max welfare	6.9779 ***	6.9779 ***	3.3467 ***
	(0.1082)	(0.1082)	(0.7018)
	[0.1102] ***	[0.1102] ***	[1.0915] ***
Expected total production profit	24.2933 ***	9.2244 ***	15.0689 ***
	(5.1932)	(1.6019)	(3.6289)

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.15: (continued)

	All firms	OPEC firms	Non-OPEC firms
	[8.8383] ***	[2.7112] ***	[6.1271] ***
Expected avg. production profit	0.4859 ***	0.8386 ***	0.3864 ***
	(0.1039)	(0.1492)	(0.0928)
	[0.1768] ***	[0.2535] ***	[0.1565] ***
Min production profit	0.0050	0.0108	-0.0751
	(0.0983)	(0.0782)	(0.0651)
	[0.1640] ***	[0.0073]	[0.1010] ***
Max production profit	5.2986 ***	1.7624 ***	5.2986 ***
	(0.3213)	(0.1476)	(0.3213)
	[0.5122] ***	[0.2308] ***	[0.5122] ***
14: Constant in natural gas demand function for Europe increases by 25%			
Expected total welfare	119.8073 ***	50.3599 ***	69.4474 ***
	(21.3713)	(0.7528)	(21.0616)
	[23.8823] ***	[-1.3989] ***	[25.2813] ***
Expected avg. welfare	2.3961 ***	4.5782 ***	1.7807 ***
	(0.4274)	(0.0936)	(0.5373)
	[0.4776] ***	[0.0033]	[0.6401] ***
Min welfare	0.1765	0.2374	-0.1665
	(0.4283)	(0.1269)	(0.2581)
	[0.7597] ***	[-0.0165]	[0.4167] ***
Max welfare	7.0247 ***	7.0247 ***	3.0055 ***
	(0.1182)	(0.1182)	(0.6842)
	[0.1570] ***	[0.1570] ***	[0.7503] ***
Expected total production profit	23.6105 ***	8.7947 ***	14.8159 ***
	(5.7492)	(1.6758)	(4.1063)
	[8.1555] ***	[2.2814] ***	[5.8741] ***
Expected avg. production profit	0.4722 ***	0.7995 ***	0.3799 ***
	(0.1150)	(0.1556)	(0.1051)
	[0.1631] ***	[0.2145] ***	[0.1500] ***
Min production profit	-0.0006	0.1692	-0.0735
	(0.1113)	(0.0878)	(0.0732)
	[0.1584] ***	[0.1657] ***	[0.1026] ***
Max production profit	5.1871 ***	1.7226 ***	5.1871 ***

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.15: (continued)

	All firms	OPEC firms	Non-OPEC firms
	(0.3626)	(0.1491)	(0.3626)
	[0.4008] ***	[0.1909] ***	[0.4008] ***
15: Constant in natural gas demand function for Middle East increases by 25%			
Expected total welfare	123.6989 ***	51.1693 ***	72.5296 ***
	(20.2189)	(0.7178)	(19.8949)
	[27.7739] ***	[-0.5895] ***	[28.3634] ***
Expected avg. welfare	2.4740 ***	4.6518 ***	1.8597 ***
	(0.4044)	(0.0868)	(0.5080)
	[0.5555] ***	[0.0769] ***	[0.7191] ***
Min welfare	0.1185	0.2542 *	-0.1218
	(0.4141)	(0.1216)	(0.2667)
	[0.7017] ***	[0.0003]	[0.4614] ***
Max welfare	6.9893 ***	6.9893 ***	3.1133 ***
	(0.1121)	(0.1121)	(0.6492)
	[0.1216] ***	[0.1216] ***	[0.8581] ***
Expected total production profit	24.0841 ***	9.1752 ***	14.9088 ***
	(5.2153)	(1.5201)	(3.7393)
	[8.6291] ***	[2.6620] ***	[5.9670] ***
Expected avg. production profit	0.4817 ***	0.8341 ***	0.3823 ***
	(0.1043)	(0.1412)	(0.0957)
	[0.1726] ***	[0.2491] ***	[0.1524] ***
Min production profit	0.0111	0.0068	-0.0718
	(0.1025)	(0.0822)	(0.0671)
	[0.1701] ***	[0.0033]	[0.1043] ***
Max production profit	5.2160 ***	1.7551 ***	5.2160 ***
	(0.3154)	(0.1366)	(0.3154)
	[0.4296] ***	[0.2235] ***	[0.4296] ***
16: Constant in natural gas demand function for America increases by 25%			
Expected total welfare	84.8890 ***	50.3551 ***	34.5338
	(21.1974)	(0.7237)	(20.8881)
	[-11.0360] ***	[-1.4037] ***	[-9.6323] ***
Expected avg. welfare	1.6978 ***	4.4471 ***	0.8918

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.15: (continued)

	All firms	OPEC firms	Non-OPEC firms
	(0.4239)	(0.0930)	(0.5334)
	[-0.2207] ***	[-0.1278] ***	[-0.2488] ***
Min welfare	-0.6327	0.2383	-0.6327 *
	(0.4337)	(0.1396)	(0.2792)
	[-0.0495]	[-0.0157]	[-0.0495]
Max welfare	6.7680 ***	6.7680 ***	1.8956 **
	(0.1182)	(0.1182)	(0.6929)
	[-0.0997] ***	[-0.0997] ***	[-0.3596] ***
Expected total production profit	13.5597 *	5.7141 ***	7.8456 *
	(5.6110)	(1.6507)	(4.0024)
	[-1.8953] ***	[-0.7991] ***	[-1.0962] ***
Expected avg. production profit	0.2712 *	0.5124 ***	0.2018 *
	(0.1122)	(0.1534)	(0.1024)
	[-0.0379] ***	[-0.0726] ***	[-0.0281] ***
Min production profit	-0.1869	0.0040	-0.1730 *
	(0.1085)	(0.0908)	(0.0729)
	[-0.0279] ***	[0.0005]	[0.0031]
Max production profit	4.6918 ***	1.4458 ***	4.6918 ***
	(0.3572)	(0.1476)	(0.3572)
	[-0.0946] ***	[-0.0858] ***	[-0.0946] ***

Notes: Welfare is in billions of dollars per year. Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.16: Summary stats for actions, constant in both oil and all regional natural gas demand functions decreases by 10%

	All firms		OPEC firms		Non-OPEC firms	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Oil output (KBD)	1503.514 ***	1796.073 ***	2512.852 ***	2562.346 ***	1028.842 ***	967.779 ***
	(45.847)	(75.038)	(168.956)	(119.872)	(9.900)	(8.928)
	[0.000]		[0.000]		[0.000]	
Natural gas output (MCFD)	3874.760 ***	7502.254 ***	3336.468 ***	3383.802 ***	4135.609 ***	8784.601 ***
	(160.582)	(98.225)	(242.525)	(147.381)	(121.610)	(111.721)
	[0.000]		[0.000]		[0.000]	
Exploration capex (million 2005 US$)	679.122 ***	897.901 ***	1126.927 ***	1139.218 ***	466.955 ***	657.581 ***
	(19.288)	(9.120)	(36.051)	(10.364)	(20.156)	(11.722)
	[0.000]		[0.000]		[0.000]	
Development capex (million 2005 US$)	1832.241 ***	2577.189 ***	3091.026 ***	3421.532 ***	1232.528 ***	1766.299 ***
	(22.488)	(20.805)	(85.407)	(27.553)	(14.856)	(16.664)
	[0.000]		[0.000]		[0.000]	
Acquisition capex (million 2005 US$)	776.833 ***	1376.407 ***	499.663 ***	954.628 ***	908.868 ***	1517.305 ***
	(18.978)	(25.530)	(7.113)	(7.281)	(26.346)	(30.693)
	[0.000]		[0.000]		[0.000]	
Dummy for M&A at time t						
merging	0.174	0.379			0.000	0.000
	(0.002)	(0.001)			(0.002)	(0.001)
	[0.000]				[0.000]	
acquiring another firm	0.048 ***	0.212 ***			0.062 ***	0.240 ***
	(0.004)	(0.008)			(0.004)	(0.009)
	[0.000]				[0.000]	
being acquired by another firm	0.003 ***	0.036 ***			0.003 ***	0.041 ***
	(0.000)	(0.002)			(0.000)	(0.003)
	[0.000]				[0.000]	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.17: Summary stats for actions, constant in both oil and all regional natural gas demand functions decreases by 25%

	All firms		OPEC firms		Non-OPEC firms	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Oil output (KBD)	1495.383 ***	1764.300 ***	2504.144 ***	2531.492 ***	1029.882 ***	957.402 ***
	(43.035)	(71.570)	(158.158)	(113.496)	(10.978)	(9.469)
	[-8.130] *		[-8.708]		[1.040]	
Natural gas output (MCFD)	3797.532 ***	7368.994 ***	3408.973 ***	3391.609 ***	3978.407 ***	8584.676 ***
	(147.453)	(86.275)	(224.978)	(138.532)	(115.090)	(110.037)
	[-77.228] ***		[72.506] ***		[-157.202] ***	
Exploration capex (million 2005 US$)	700.654 ***	898.386 ***	1193.958 ***	1130.993 ***	472.693 ***	652.756 ***
	(20.700)	(9.206)	(37.795)	(9.238)	(20.691)	(12.264)
	[21.532] ***		[67.031] ***		[5.737] ***	
Development capex (million 2005 US$)	1840.080 ***	2573.289 ***	3241.397 ***	3415.289 ***	1192.561 ***	1722.298 ***
	(23.824)	(20.329)	(92.422)	(25.963)	(16.042)	(16.332)
	[7.839] ***		[150.371] ***		[-39.967] ***	
Acquisition capex (million 2005 US$)	748.304 ***	1332.768 ***	506.488 ***	957.781 ***	860.322 ***	1457.826 ***
	(20.526)	(27.959)	(5.834)	(7.238)	(29.470)	(34.854)
	[-28.529] ***		[6.825] ***		[-48.546] ***	
Dummy for M&A at time t						
merging	0.176	0.381			0.000	0.000
	(0.002)	(0.002)			(0.002)	(0.001)
	[0.002] ***				[0.001] ***	
acquiring another firm	0.043 ***	0.200 ***			0.055 ***	0.225 ***
	(0.004)	(0.009)			(0.005)	(0.010)
	[-0.005] ***				[-0.007] ***	
being acquired by another firm	0.002 ***	0.035 ***			0.003 ***	0.040 ***
	(0.000)	(0.002)			(0.000)	(0.003)
	[0.000] ***				[0.000] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.18: Summary stats for actions, constant in oil demand function decreases by 10%

Variable	All firms Mean	All firms Std. Dev.	OPEC firms Mean	OPEC firms Std. Dev.	Non-OPEC firms Mean	Non-OPEC firms Std. Dev.
Oil output (KBD)	1585.672 ***	1922.426 ***	2809.424 ***	2765.730 ***	1025.757 ***	956.729 ***
	(43.390)	(73.637)	(160.835)	(116.751)	(10.488)	(8.966)
	[82.158] ***		[296.571] ***		[-3.084] ***	
Natural gas output (MCFD)	4080.961 ***	7401.377 ***	3749.786 ***	3628.362 ***	4231.871 ***	8570.001 ***
	(156.266)	(104.532)	(226.408)	(140.618)	(125.339)	(122.058)
	[206.201] ***		[413.318] ***		[96.262] ***	
Exploration capex (million 2005 US$)	650.790 ***	887.838 ***	1135.441 ***	1139.176 ***	429.108 ***	633.221 ***
	(20.337)	(9.364)	(34.069)	(10.512)	(20.611)	(11.732)
	[-28.332] ***		[8.514] **		[-37.847] ***	
Development capex (million 2005 US$)	1822.129 ***	2561.075 ***	3118.547 ***	3431.395 ***	1229.144 ***	1749.864 ***
	(22.387)	(21.420)	(82.081)	(28.836)	(15.837)	(18.147)
	[-10.112] ***		[27.521] ***		[-3.384] **	
Acquisition capex (million 2005 US$)	797.016 ***	1401.768 ***	498.073 ***	954.930 ***	934.073 ***	1542.961 ***
	(21.884)	(28.797)	(6.754)	(7.308)	(30.083)	(34.661)
	[20.183] ***		[-1.590] **		[25.205] ***	
Dummy for M&A at time t						
merging	0.176	0.381			0.000	0.000
	(0.001)	(0.001)			(0.001)	(0.001)
	[0.002] ***				[0.000] *	
acquiring another firm	0.050 ***	0.217 ***			0.064 ***	0.243 ***
	(0.004)	(0.010)			(0.005)	(0.010)
	[0.002] ***				[0.002] ***	
being acquired by another firm	0.002 ***	0.031 ***			0.003 ***	0.035 ***
	(0.000)	(0.002)			(0.000)	(0.003)
	[0.000] ***				[-0.001] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.19: Summary stats for actions, constant in oil demand function decreases by 25%

Variable	All firms Mean	All firms Std. Dev.	OPEC firms Mean	OPEC firms Std. Dev.	Non-OPEC firms Mean	Non-OPEC firms Std. Dev.
Oil output (KBD)	1402.028 ***	1608.666 ***	2127.792 ***	2264.326 ***	1039.731 ***	963.256 ***
	(46.256)	(78.101)	(169.017)	(123.246)	(9.863)	(9.718)
	[-101.486] ***		[-385.061] ***		[10.889] ***	
Natural gas output (MCFD)	3489.969 ***	7270.743 ***	2829.819 ***	3059.048 ***	3825.120 ***	8610.861 ***
	(170.250)	(110.992)	(236.086)	(148.859)	(139.705)	(125.504)
	[-384.791] ***		[-506.648] ***		[-310.489] ***	
Exploration capex (million 2005 US$)	729.198 ***	916.620 ***	1145.889 ***	1153.559 ***	520.723 ***	680.035 ***
	(21.509)	(9.065)	(33.093)	(9.191)	(21.546)	(11.854)
	[50.075] ***		[18.962] ***		[53.767] ***	
Development capex (million 2005 US$)	1863.896 ***	2620.071 ***	3165.521 ***	3465.616 ***	1211.275 ***	1729.150 ***
	(23.208)	(20.260)	(79.433)	(26.226)	(18.220)	(20.143)
	[31.654] ***		[74.495] ***		[-21.254] ***	
Acquisition capex (million 2005 US$)	727.988 ***	1306.664 ***	505.546 ***	963.538 ***	840.808 ***	1432.955 ***
	(21.741)	(29.311)	(6.433)	(7.476)	(30.331)	(35.423)
	[-48.845] ***		[5.883] ***		[-68.060] ***	
Dummy for M&A at time t						
merging	0.176	0.381			0.000	0.000
	(0.001)	(0.001)			(0.001)	(0.001)
	[0.002] ***				[0.004] ***	
acquiring another firm	0.038 ***	0.188 ***			0.049 ***	0.214 ***
	(0.004)	(0.010)			(0.005)	(0.011)
	[-0.010] ***				[-0.013] ***	
being acquired by another firm	0.003 ***	0.037 ***			0.004 ***	0.043 ***
	(0.000)	(0.003)			(0.000)	(0.003)
	[0.000] ***				[0.000] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.20: Summary stats for actions, constant in natural gas demand function for Africa decreases by 25%

Variable	All firms Mean	All firms Std. Dev.	OPEC firms Mean	OPEC firms Std. Dev.	Non-OPEC firms Mean	Non-OPEC firms Std. Dev.
Oil output (KBD)	1491.922 ***	1729.359 ***	2462.258 ***	2479.030 ***	1044.761 ***	957.112 ***
	(42.453)	(68.611)	(151.400)	(108.697)	(9.266)	(8.926)
	[-11.592] **		[-50.594] ***		[15.919] ***	
Natural gas output (MCFD)	3753.621 ***	7363.940 ***	3340.212 ***	3348.845 ***	3945.538 ***	8585.821 ***
	(150.246)	(101.888)	(216.698)	(134.176)	(120.465)	(119.348)
	[-121.139] ***		[3.744]		[-190.071] ***	
Exploration capex (million 2005 US$)	716.639 ***	910.632 ***	1217.500 ***	1149.008 ***	485.544 ***	660.191 ***
	(18.426)	(7.997)	(35.619)	(9.014)	(18.152)	(10.220)
	[37.517] ***		[90.573] ***		[18.588] ***	
Development capex (million 2005 US$)	1865.686 ***	2601.420 ***	3318.687 ***	3449.708 ***	1194.939 ***	1725.738 ***
	(23.010)	(18.914)	(84.797)	(26.349)	(16.347)	(17.211)
	[33.445] ***		[227.661] ***		[-37.590] ***	
Acquisition capex (million 2005 US$)	744.786 ***	1335.833 ***	494.032 ***	957.642 ***	860.317 ***	1459.865 ***
	(19.417)	(26.166)	(6.670)	(6.797)	(27.915)	(32.429)
	[-32.047] ***		[-5.631] ***		[-48.551] ***	
Dummy for M&A at time t						
merging	0.176	0.381			0.000	0.000
	(0.002)	(0.001)			(0.002)	(0.001)
	[0.002] ***				[0.001] ***	
acquiring another firm	0.042 ***	0.197 ***			0.054 ***	0.222 ***
	(0.004)	(0.009)			(0.005)	(0.010)
	[-0.006] ***				[-0.009] ***	
being acquired by another firm	0.002 ***	0.035 ***			0.003 ***	0.040 ***
	(0.000)	(0.003)			(0.000)	(0.003)
	[0.000] ***				[0.000] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.21: Summary stats for actions, constant in natural gas demand function for Asia & Oceania decreases by 25%

	All firms		OPEC firms		Non-OPEC firms	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Oil output (KBD)	1429.929 ***	1634.896 ***	2225.545 ***	2314.965 ***	1047.943 ***	970.469 ***
	(43.359)	(74.800)	(161.525)	(118.037)	(13.078)	(9.609)
	[-73.585] ***		[-287.307] ***		[19.102] ***	
Natural gas output (MCFD)	3558.367 ***	7445.688 ***	2979.089 ***	3128.301 ***	3844.061 ***	8779.037 ***
	(156.470)	(96.250)	(228.602)	(142.627)	(123.333)	(109.382)
	[-316.393] ***		[-357.379] ***		[-291.548] ***	
Exploration capex (million 2005 US$)	731.931 ***	920.725 ***	1190.098 ***	1156.348 ***	511.846 ***	680.035 ***
	(22.345)	(10.222)	(38.498)	(10.664)	(21.461)	(12.011)
	[52.809] ***		[63.170] ***		[44.891] ***	
Development capex (million 2005 US$)	1868.654 ***	2631.451 ***	3269.052 ***	3473.321 ***	1194.774 ***	1744.764 ***
	(26.834)	(23.647)	(96.739)	(29.615)	(14.959)	(15.979)
	[36.413] ***		[178.027] ***		[-37.755] ***	
Acquisition capex (million 2005 US$)	723.635 ***	1301.077 ***	522.074 ***	979.443 ***	821.124 ***	1417.506 ***
	(21.797)	(29.055)	(6.878)	(8.073)	(30.587)	(35.351)
	[-53.198] ***		[22.411] ***		[-87.743] ***	
Dummy for M&A at time t						
merging	0.173	0.379			0.000	0.000
	(0.002)	(0.001)			(0.001)	(0.001)
	[-0.001] ***				[-0.001] ***	
acquiring another firm	0.038 ***	0.188 ***			0.049 ***	0.213 ***
	(0.004)	(0.010)			(0.005)	(0.011)
	[-0.010] ***				[-0.013] ***	
being acquired by another firm	0.003 ***	0.036 ***			0.003 ***	0.041 ***
	(0.000)	(0.003)			(0.000)	(0.003)
	[0.000]				[0.000]	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.22: Summary stats for actions, constant in natural gas demand function for Eurasia decreases by 25%

Variable	All firms Mean	All firms Std. Dev.	OPEC firms Mean	OPEC firms Std. Dev.	Non-OPEC firms Mean	Non-OPEC firms Std. Dev.
Oil output (KBD)	1486.584 ***	1703.470 ***	2423.179 ***	2445.005 ***	1049.176 ***	941.355 ***
	(42.751)	(74.045)	(157.355)	(116.086)	(11.648)	(8.213)
	[-16.929] ***		[-89.673] ***		[20.335] ***	
Natural gas output (MCFD)	3724.608 ***	7241.549 ***	3311.107 ***	3336.755 ***	3916.496 ***	8441.768 ***
	(155.976)	(98.033)	(217.412)	(138.041)	(128.758)	(110.992)
	[-150.152] ***		[-25.361]		[-219.113] ***	
Exploration capex (million 2005 US$)	752.060 ***	932.367 ***	1276.800 ***	1171.130 ***	507.182 ***	669.964 ***
	(20.831)	(9.711)	(31.668)	(10.625)	(20.983)	(11.642)
	[72.937] ***		[149.873] ***		[40.226] ***	
Development capex (million 2005 US$)	1926.997 ***	2644.715 ***	3460.217 ***	3496.158 ***	1211.071 ***	1716.321 ***
	(22.277)	(22.471)	(80.991)	(30.627)	(15.781)	(17.702)
	[94.756] ***		[369.191] ***		[-21.458] ***	
Acquisition capex (million 2005 US$)	724.111 ***	1301.976 ***	507.856 ***	964.727 ***	825.256 ***	1418.261 ***
	(21.614)	(28.818)	(7.024)	(7.690)	(30.635)	(35.272)
	[-52.722] ***		[8.193] ***		[-83.612] ***	
Dummy for M&A at time t						
merging	0.177	0.382			0.000	0.000
	(0.002)	(0.001)			(0.002)	(0.001)
	[0.003] ***				[0.002] ***	
acquiring another firm	0.037 ***	0.187 ***			0.048 ***	0.211 ***
	(0.004)	(0.010)			(0.005)	(0.011)
	[-0.011] ***				[-0.015] ***	
being acquired by another firm	0.003 ***	0.038 ***			0.003 ***	0.043 ***
	(0.000)	(0.003)			(0.000)	(0.003)
	[0.000] ***				[0.000] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.23: Summary stats for actions, constant in natural gas demand function for Europe decreases by 25%

	All firms		OPEC firms		Non-OPEC firms	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Oil output (KBD)	1512.318 ***	1766.148 ***	2515.239 ***	2521.437 ***	1046.265 ***	969.198 ***
	(42.263)	(70.474)	(153.741)	(110.744)	(9.741)	(8.645)
	[8.804] *		[2.387]		[17.424] ***	
Natural gas output (MCFD)	3852.826 ***	7564.477 ***	3387.440 ***	3378.272 ***	4068.103 ***	8838.198 ***
	(149.421)	(109.364)	(214.236)	(133.327)	(121.046)	(126.835)
	[-21.934]		[50.973] **		[-67.506] ***	
Exploration capex (million 2005 US$)	712.457 ***	916.635 ***	1201.530 ***	1157.782 ***	485.212 ***	668.655 ***
	(19.886)	(8.748)	(31.314)	(9.376)	(19.815)	(10.885)
	[33.335] ***		[74.603] ***		[18.257] ***	
Development capex (million 2005 US$)	1882.002 ***	2625.074 ***	3308.555 ***	3478.969 ***	1219.044 ***	1756.550 ***
	(21.518)	(19.796)	(76.164)	(25.403)	(14.551)	(17.941)
	[49.761] ***		[217.530] ***		[-13.485] ***	
Acquisition capex (million 2005 US$)	744.389 ***	1334.294 ***	502.324 ***	963.988 ***	857.033 ***	1458.669 ***
	(19.759)	(26.618)	(5.955)	(7.211)	(27.383)	(31.993)
	[-32.444] ***		[2.662] ***		[-51.835] ***	
Dummy for M&A at time t						
merging	0.177	0.382			0.000	0.000
	(0.001)	(0.001)			(0.001)	(0.001)
	[0.003] ***				[0.002] ***	
acquiring another firm	0.040 ***	0.194 ***			0.051 ***	0.218 ***
	(0.004)	(0.008)			(0.005)	(0.009)
	[-0.008] ***				[-0.011] ***	
being acquired by another firm	0.002 ***	0.033 ***			0.003 ***	0.037 ***
	(0.000)	(0.003)			(0.000)	(0.003)
	[0.000] ***				[0.000] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.24: Summary stats for actions, constant in natural gas demand function for Middle East decreases by 25%

	All firms		OPEC firms		Non-OPEC firms	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Oil output (KBD)	1460.284 ***	1720.432 ***	2362.379 ***	2447.049 ***	1034.758 ***	975.974 ***
	(44.597)	(74.407)	(164.386)	(118.538)	(11.837)	(8.731)
	[-43.230] ***		[-150.473] ***		[5.916] ***	
Natural gas output (MCFD)	3704.004 ***	7499.661 ***	3143.772 ***	3244.173 ***	3978.551 ***	8818.231 ***
	(160.382)	(97.170)	(236.110)	(145.933)	(125.742)	(112.091)
	[-170.756] ***		[-192.696] ***		[-157.058] ***	
Exploration capex (million 2005 US$)	697.157 ***	907.917 ***	1139.656 ***	1147.270 ***	486.601 ***	673.556 ***
	(19.952)	(9.503)	(36.921)	(11.079)	(20.119)	(11.580)
	[18.035] ***		[12.729] ***		[19.646] ***	
Development capex (million 2005 US$)	1838.058 ***	2603.799 ***	3153.301 ***	3464.708 ***	1210.093 ***	1749.607 ***
	(23.906)	(22.558)	(90.608)	(31.202)	(15.003)	(17.251)
	[5.817] **		[62.275] ***		[-22.435] ***	
Acquisition capex (million 2005 US$)	750.565 ***	1337.047 ***	495.543 ***	949.423 ***	871.982 ***	1467.127 ***
	(19.979)	(26.876)	(6.564)	(7.490)	(28.225)	(32.907)
	[-26.268] ***		[-4.120] ***		[-36.886] ***	
Dummy for M&A at time t						
merging	0.173	0.378			0.000	0.000
	(0.002)	(0.001)			(0.002)	(0.001)
	[-0.001] ***				[-0.001] ***	
acquiring another firm	0.042 ***	0.197 ***			0.054 ***	0.223 ***
	(0.004)	(0.009)			(0.005)	(0.010)
	[-0.006] ***				[-0.008] ***	
being acquired by another firm	0.002 ***	0.032 ***			0.003 ***	0.037 ***
	(0.000)	(0.003)			(0.000)	(0.003)
	[0.000] ***				[0.000] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.25: Summary stats for actions, constant in natural gas demand function for America decreases by 25%

Variable	All firms Mean	All firms Std. Dev.	OPEC firms Mean	OPEC firms Std. Dev.	Non-OPEC firms Mean	Non-OPEC firms Std. Dev.
Oil output (KBD)	1521.680 ***	1823.465 ***	2559.122 ***	2595.801 ***	1028.934 ***	963.740 ***
	(47.432)	(79.191)	(173.225)	(124.510)	(12.488)	(8.793)
	[18.166] ***		[46.270] ***		[0.093]	
Natural gas output (MCFD)	3873.950 ***	7376.996 ***	3386.274 ***	3412.916 ***	4114.960 ***	8633.082 ***
	(163.242)	(113.629)	(244.330)	(150.881)	(129.016)	(141.790)
	[-0.810]		[49.806] *		[-20.648] *	
Exploration capex (million 2005 US$)	675.856 ***	901.544 ***	1117.003 ***	1148.518 ***	464.319 ***	657.144 ***
	(22.460)	(10.107)	(38.564)	(11.199)	(22.550)	(12.663)
	[-3.266]		[-9.925] **		[-2.637]	
Development capex (million 2005 US$)	1823.090 ***	2586.055 ***	3061.470 ***	3452.901 ***	1225.614 ***	1751.883 ***
	(25.614)	(23.972)	(94.766)	(31.313)	(16.790)	(20.264)
	[-9.151] ***		[-29.556] ***		[-6.914] ***	
Acquisition capex (million 2005 US$)	781.902 ***	1380.712 ***	495.419 ***	958.979 ***	919.480 ***	1521.162 ***
	(23.556)	(31.014)	(6.299)	(7.559)	(32.716)	(37.541)
	[5.069] **		[-4.243] ***		[10.612] ***	
Dummy for M&A at time t						
merging	0.174	0.379			0.000	0.000
	(0.002)	(0.002)			(0.002)	(0.001)
	[0.000]				[0.000]	
acquiring another firm	0.048 ***	0.211 ***			0.062 ***	0.238 ***
	(0.004)	(0.010)			(0.006)	(0.011)
	[0.000]				[-0.001]	
being acquired by another firm	0.002 ***	0.031 ***			0.003 ***	0.035 ***
	(0.000)	(0.003)			(0.000)	(0.003)
	[0.000] ***				[0.000] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.26: Summary stats for actions, Constant in natural gas demand function for Africa increases by 25%

Variable	All firms Mean	All firms Std. Dev.	OPEC firms Mean	OPEC firms Std. Dev.	Non-OPEC firms Mean	Non-OPEC firms Std. Dev.
Oil output (KBD)	1431.283 ***	1693.082 ***	2261.246 ***	2391.406 ***	1026.125 ***	974.201 ***
	(50.411)	(81.624)	(183.694)	(129.005)	(10.068)	(8.988)
	[-72.230] ***		[-251.607] ***		[-2.716] **	
Natural gas output (MCFD)	3635.217 ***	7366.086 ***	2985.634 ***	3172.323 ***	3961.719 ***	8696.095 ***
	(168.243)	(99.437)	(260.998)	(159.246)	(125.657)	(123.878)
	[-239.544] ***		[-350.834] ***		[-173.890] ***	
Exploration capex (million 2005 US$)	695.893 ***	906.888 ***	1099.475 ***	1147.419 ***	496.144 ***	675.918 ***
	(20.535)	(8.831)	(34.566)	(9.965)	(22.985)	(13.240)
	[16.771] ***		[-27.452] ***		[29.188] ***	
Development capex (million 2005 US$)	1822.719 ***	2591.978 ***	3036.042 ***	3447.167 ***	1219.388 ***	1747.906 ***
	(20.747)	(19.650)	(81.913)	(27.053)	(15.162)	(16.954)
	[-9.522] ***		[-54.983] ***		[-13.141] ***	
Acquisition capex (million 2005 US$)	754.843 ***	1346.455 ***	493.924 ***	948.758 ***	884.013 ***	1485.499 ***
	(20.073)	(26.607)	(6.798)	(7.537)	(28.012)	(32.106)
	[-21.990] ***		[-5.739] ***		[-24.855] ***	
Dummy for M&A at time t						
merging	0.173	0.378			0.000	0.000
	(0.002)	(0.001)			(0.001)	(0.001)
	[-0.001] ***				[0.001] ***	
acquiring another firm	0.045 ***	0.204 ***			0.058 ***	0.232 ***
	(0.004)	(0.008)			(0.005)	(0.009)
	[-0.004] ***				[-0.004] ***	
being acquired by another firm	0.002 ***	0.034 ***			0.003 ***	0.039 ***
	(0.000)	(0.002)			(0.000)	(0.003)
	[0.000] ***				[0.000] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.27: Summary stats for actions, constant in natural gas demand function for Asia & Oceania increases by 25%

	All firms		OPEC firms		Non-OPEC firms	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Oil output (KBD)	1568.424 ***	1901.360 ***	2763.501 ***	2729.923 ***	1019.719 ***	960.056 ***
	(44.336)	(77.690)	(163.093)	(121.070)	(12.150)	(9.087)
	[64.910] ***		[250.649] ***		[-9.123] ***	
Natural gas output (MCFD)	4037.341 ***	7414.657 ***	3708.866 ***	3591.198 ***	4186.834 ***	8595.346 ***
	(158.570)	(99.764)	(224.703)	(142.131)	(130.838)	(118.832)
	[162.581] ***		[372.398] ***		[51.226] ***	
Exploration capex (million 2005 US$)	666.001 ***	894.629 ***	1154.749 ***	1137.721 ***	441.479 ***	644.078 ***
	(22.978)	(9.487)	(36.969)	(10.286)	(21.877)	(11.725)
	[-13.121] ***		[27.822] ***		[-25.476] ***	
Development capex (million 2005 US$)	1833.885 ***	2564.809 ***	3151.219 ***	3423.267 ***	1228.405 ***	1748.986 ***
	(23.162)	(22.357)	(91.145)	(29.671)	(16.796)	(18.033)
	[1.644]		[60.194] ***		[-4.123] **	
Acquisition capex (million 2005 US$)	785.380 ***	1385.996 ***	498.890 ***	949.446 ***	917.161 ***	1524.779 ***
	(23.590)	(31.746)	(6.342)	(6.744)	(33.411)	(38.853)
	[8.547] ***		[-0.772]		[8.293] ***	
Dummy for M&A at time t						
merging	0.176	0.381			0.000	0.000
	(0.002)	(0.001)			(0.002)	(0.001)
	[0.002] ***				[0.001] ***	
acquiring another firm	0.049 ***	0.214 ***			0.063 ***	0.241 ***
	(0.004)	(0.010)			(0.006)	(0.011)
	[0.001] *				[0.000]	
being acquired by another firm	0.002 ***	0.030 ***			0.003 ***	0.034 ***
	(0.000)	(0.003)			(0.000)	(0.003)
	[0.000] ***				[-0.001] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.28: Summary stats for actions, constant in natural gas demand function for Eurasia increases by 25%

Variable	All firms Mean	All firms Std. Dev.	OPEC firms Mean	OPEC firms Std. Dev.	Non-OPEC firms Mean	Non-OPEC firms Std. Dev.
Oil output (KBD)	1523.233 ***	1811.040 ***	2613.869 ***	2603.163 ***	1024.902 ***	953.081 ***
	(44.603)	(73.107)	(165.013)	(117.649)	(10.827)	(8.765)
	[19.719] ***		[101.016] ***		[-3.940] ***	
Natural gas output (MCFD)	3937.498 ***	7478.045 ***	3558.261 ***	3480.150 ***	4111.977 ***	8696.263 ***
	(157.684)	(90.857)	(236.404)	(144.881)	(120.045)	(101.175)
	[62.738] ***		[221.794] ***		[-23.632] *	
Exploration capex (million 2005 US$)	697.465 ***	906.164 ***	1203.701 ***	1145.915 ***	465.841 ***	653.565 ***
	(18.779)	(8.564)	(32.249)	(9.529)	(20.318)	(11.643)
	[18.343] ***		[76.774] ***		[-1.114]	
Development capex (million 2005 US$)	1864.347 ***	2590.506 ***	3267.068 ***	3435.130 ***	1222.274 ***	1752.834 ***
	(20.350)	(19.513)	(76.404)	(27.275)	(14.292)	(15.688)
	[32.106] ***		[176.042] ***		[-10.254] ***	
Acquisition capex (million 2005 US$)	762.974 ***	1353.681 ***	509.569 ***	966.515 ***	878.507 ***	1479.601 ***
	(19.049)	(26.239)	(6.972)	(7.841)	(26.024)	(31.342)
	[-13.859] ***		[9.907] ***		[-30.361] ***	
Dummy for M&A at time t						
merging	0.179	0.383			0.000	0.000
	(0.002)	(0.002)			(0.002)	(0.001)
	[0.005] ***				[0.004] ***	
acquiring another firm	0.044 ***	0.204 ***			0.057 ***	0.229 ***
	(0.004)	(0.009)			(0.005)	(0.009)
	[-0.004] ***				[-0.005] ***	
being acquired by another firm	0.002 ***	0.031 ***			0.003 ***	0.036 ***
	(0.000)	(0.002)			(0.000)	(0.003)
	[0.000] ***				[-0.001] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.29: Summary stats for actions, constant in natural gas demand function for Europe increases by 25%

Variable	All firms Mean	All firms Std. Dev.	OPEC firms Mean	OPEC firms Std. Dev.	Non-OPEC firms Mean	Non-OPEC firms Std. Dev.
Oil output (KBD)	1514.724 ***	1763.822 ***	2516.853 ***	2522.187 ***	1049.714 ***	965.085 ***
	(41.345)	(68.607)	(147.530)	(107.137)	(11.164)	(8.369)
	[11.210] **		[4.001]		[20.873] ***	
Natural gas output (MCFD)	3805.615 ***	7373.182 ***	3386.186 ***	3390.016 ***	3999.986 ***	8591.823 ***
	(145.436)	(101.580)	(206.395)	(129.580)	(121.421)	(122.300)
	[-69.146] ***		[49.718] **		[-135.622] ***	
Exploration capex (million 2005 US$)	710.545 ***	912.853 ***	1201.876 ***	1156.007 ***	482.349 ***	661.321 ***
	(20.071)	(9.288)	(35.468)	(10.686)	(19.175)	(11.008)
	[31.423] ***		[74.949] ***		[15.394] ***	
Development capex (million 2005 US$)	1869.253 ***	2611.923 ***	3299.204 ***	3475.018 ***	1204.497 ***	1727.067 ***
	(24.467)	(21.401)	(89.246)	(28.504)	(17.021)	(18.600)
	[37.011] ***		[208.179] ***		[-28.032] ***	
Acquisition capex (million 2005 US$)	748.286 ***	1326.708 ***	504.650 ***	958.217 ***	861.741 ***	1449.851 ***
	(20.465)	(27.923)	(6.403)	(7.612)	(29.384)	(34.397)
	[-28.547] ***		[4.988] ***		[-47.127] ***	
Dummy for M&A at time t						
merging	0.178	0.383			0.000	0.000
	(0.002)	(0.001)			(0.002)	(0.001)
	[0.004] ***				[0.003] ***	
acquiring another firm	0.040 ***	0.194 ***			0.052 ***	0.219 ***
	(0.004)	(0.009)			(0.005)	(0.010)
	[-0.008] ***				[-0.010] ***	
being acquired by another firm	0.002 ***	0.034 ***			0.003 ***	0.038 ***
	(0.000)	(0.003)			(0.000)	(0.003)
	[0.000] ***				[0.000] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.30: Summary stats for actions, constant in natural gas demand function for Middle East increases by 25%

Variable	All firms Mean	All firms Std. Dev.	OPEC firms Mean	OPEC firms Std. Dev.	Non-OPEC firms Mean	Non-OPEC firms Std. Dev.
Oil output (KBD)	1532.091 ***	1810.139 ***	2609.167 ***	2589.962 ***	1032.522 ***	957.424 ***
	(44.342)	(74.216)	(159.440)	(115.972)	(9.458)	(7.762)
	[28.577] ***		[96.314] ***		[3.680] ***	
Natural gas output (MCFD)	3952.079 ***	7450.612 ***	3559.863 ***	3491.720 ***	4134.865 ***	8673.686 ***
	(158.345)	(105.909)	(221.409)	(138.177)	(130.922)	(121.900)
	[77.319] ***		[223.395] ***		[-0.744]	
Exploration capex (million 2005 US$)	701.416 ***	907.465 ***	1203.377 ***	1144.468 ***	468.648 ***	655.648 ***
	(20.047)	(8.634)	(32.346)	(9.374)	(20.102)	(10.747)
	[22.294] ***		[76.450] ***		[1.693]	
Development capex (million 2005 US$)	1870.898 ***	2590.387 ***	3251.192 ***	3433.232 ***	1230.643 ***	1751.173 ***
	(21.578)	(19.524)	(78.752)	(25.236)	(16.667)	(19.137)
	[38.657] ***		[160.167] ***		[-1.885]	
Acquisition capex (million 2005 US$)	751.649 ***	1346.006 ***	498.030 ***	955.978 ***	868.865 ***	1473.889 ***
	(20.708)	(27.735)	(6.968)	(7.820)	(29.217)	(33.836)
	[-25.184] ***		[-1.633] **		[-40.003] ***	
Dummy for M&A at time t						
merging	0.178	0.383			0.000	0.000
	(0.002)	(0.001)			(0.002)	(0.001)
	[0.004] ***				[0.004] ***	
acquiring another firm	0.044 ***	0.202 ***			0.056 ***	0.227 ***
	(0.004)	(0.009)			(0.005)	(0.010)
	[-0.004] ***				[-0.006] ***	
being acquired by another firm	0.002 ***	0.035 ***			0.003 ***	0.040 ***
	(0.000)	(0.003)			(0.000)	(0.003)
	[0.000] ***				[0.000] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.31: Summary stats for actions, constant in natural gas demand function for America increases by 25%

Variable	All firms Mean	All firms Std. Dev.	OPEC firms Mean	OPEC firms Std. Dev.	Non-OPEC firms Mean	Non-OPEC firms Std. Dev.
Oil output (KBD)	1465.127 ***	1719.760 ***	2363.776 ***	2448.599 ***	1041.671 ***	975.859 ***
	(44.205)	(74.385)	(161.908)	(116.991)	(12.008)	(8.835)
	[-38.387] ***		[-149.076] ***		[12.830] ***	
Natural gas output (MCFD)	3681.177 ***	7431.964 ***	3138.715 ***	3247.335 ***	3947.500 ***	8725.306 ***
	(155.143)	(109.819)	(229.645)	(142.010)	(122.697)	(133.286)
	[-193.583] ***		[-197.752] ***		[-188.108] ***	
Exploration capex (million 2005 US$)	694.502 ***	905.109 ***	1139.739 ***	1148.791 ***	483.330 ***	665.098 ***
	(20.207)	(9.439)	(33.369)	(10.955)	(21.003)	(11.943)
	[15.380] ***		[12.812] ***		[16.374] ***	
Development capex (million 2005 US$)	1834.279 ***	2600.024 ***	3153.786 ***	3463.513 ***	1205.450 ***	1743.071 ***
	(22.591)	(22.847)	(82.866)	(31.847)	(15.890)	(18.754)
	[2.037]		[62.761] ***		[-27.079] ***	
Acquisition capex (million 2005 US$)	749.792 ***	1336.224 ***	499.719 ***	957.414 ***	869.324 ***	1465.165 ***
	(20.293)	(28.380)	(5.748)	(6.406)	(28.685)	(34.575)
	[-27.041] ***		[0.057]		[-39.544] ***	
Dummy for M&A at time t						
merging	0.175	0.380			0.000	0.000
	(0.002)	(0.001)			(0.001)	(0.001)
	[0.001] ***				[0.001] ***	
acquiring another firm	0.042 ***	0.197 ***			0.054 ***	0.223 ***
	(0.004)	(0.009)			(0.005)	(0.010)
	[-0.006] ***				[-0.008] ***	
being acquired by another firm	0.002 ***	0.032 ***			0.003 ***	0.036 ***
	(0.000)	(0.003)			(0.000)	(0.003)
	[0.000] ***				[-0.001] ***	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.32: Summary statistics of prices under demand shock secarios 1-4

Constants in oil demand function and all natural gas demand functions respectively decrease by:								
	(10%, 10%)		(25%, 25%)		(10%, NA)		(25%, NA)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Crude oil price, Brent (2005 US$/bbl)								
	70.5065 ***	0.0000	70.5065 ***	0.0000	70.5065 ***	0.0000	70.5065 ***	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	[0.0000]		[0.0000]		[0.0000]		[0.0000]	
Regional natural gas price (2005 US$/mmbtu)								
Africa	8.5303 ***	2.6513 ***	8.6010 ***	2.6087 ***	8.4702 ***	2.6746 ***	8.6187 ***	2.5972 ***
	(0.0377)	(0.0216)	(0.0359)	(0.0205)	(0.0369)	(0.0208)	(0.0421)	(0.0242)
	[0.0000]		[0.0707] **		[-0.0601] *		[0.0884] **	
Asia & Oceania	12.1559 ***	5.1813 ***	12.2278 ***	5.1967 ***	11.8957 ***	5.1872 ***	12.7094 ***	5.1766 ***
	(0.2211)	(0.0176)	(0.2045)	(0.0190)	(0.2119)	(0.0174)	(0.2244)	(0.0186)
	[0.0000]		[0.0720]		[-0.2602]		[0.5536] **	
Eurasia	2.1149 ***	0.0542	2.1312 ***	0.0143	2.1065 ***	0.0747 *	2.0609 ***	0.1865 ***
	(0.0129)	(0.0317)	(0.0042)	(0.0102)	(0.0147)	(0.0361)	(0.0162)	(0.0396)
	[0.0273] **		[0.0436] ***		[0.0189] *		[-0.0267] *	
Europe	6.2775 ***	2.6986 ***	6.1623 ***	2.3586 ***	6.2007 ***	2.4873 ***	6.3544 ***	2.6734 ***
	(0.0702)	(0.1445)	(0.0717)	(0.1598)	(0.0677)	(0.1394)	(0.0740)	(0.1587)
	[0.0000]		[-0.1153] *		[-0.0768]		[0.0768]	
Middle East	11.1239 ***	4.7419 ***	10.9011 ***	4.8004 ***	11.0695 ***	4.7753 ***	10.9772 ***	4.7899 ***
	(0.1087)	(0.0588)	(0.1047)	(0.0546)	(0.1122)	(0.0614)	(0.1134)	(0.0624)
	[0.0000]		[-0.2227] **		[-0.0543]		[-0.1467] *	
America	9.6838 ***	2.5450 ***	9.5931 ***	2.7671 ***	9.5894 ***	2.7764 ***	9.7254 ***	2.4432 ***
	(0.0532)	(0.1304)	(0.0547)	(0.1339)	(0.0494)	(0.1211)	(0.0476)	(0.1166)
	[0.0000]		[-0.0907] *		[-0.0945] **		[0.0416]	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation.
Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.33: Summary statistics of prices under demand shock secarios 5-7

Constant in regional natural gas demand function decreases by 25% for:						
	Africa		Asia & Oceania		Eurasia	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Crude oil price, Brent (2005 US$/bbl)						
	70.5065 ***	0.0000	70.5065 ***	0.0000	70.5065 ***	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	[0.0000]		[0.0000]		[0.0000]	
Regional natural gas price (2005 US$/mmbtu)						
Africa	8.6116 ***	2.6018 ***	8.6116 ***	2.6018 ***	8.6187 ***	2.5972 ***
	(0.0357)	(0.0199)	(0.0364)	(0.0206)	(0.0369)	(0.0211)
	[0.0813] **		[0.0813] **		[0.0884] **	
Asia & Oceania	12.2223 ***	5.2144 ***	12.6818 ***	5.1901 ***	12.4105 ***	5.2104 ***
	(0.2110)	(0.0201)	(0.2105)	(0.0211)	(0.2082)	(0.0186)
	[0.0664]		[0.5259] **		[0.2546]	
Eurasia	2.0552 ***	0.2003 ***	2.0515 ***	0.2093 ***	2.1317 ***	0.0131
	(0.0143)	(0.0351)	(0.0161)	(0.0395)	(0.0041)	(0.0100)
	[-0.0323] **		[-0.0360] **		[0.0441] ***	
Europe	6.2839 ***	2.6161 ***	6.3223 ***	2.7132 ***	6.1623 ***	2.4163 ***
	(0.0666)	(0.1395)	(0.0754)	(0.1585)	(0.0705)	(0.1541)
	[0.0064]		[0.0448]		[-0.1153] *	
Middle East	11.2651 ***	4.7392 ***	10.9609 ***	4.8840 ***	11.0206 ***	4.7895 ***
	(0.1048)	(0.0548)	(0.1100)	(0.0576)	(0.1026)	(0.0547)
	[0.1412] *		[-0.1630] *		[-0.1032]	
America	9.5894 ***	2.7764 ***	9.6725 ***	2.5728 ***	9.5894 ***	2.7764 ***
	(0.0478)	(0.1171)	(0.0525)	(0.1287)	(0.0452)	(0.1107)
	[-0.0945] **		[-0.0113]		[-0.0945] **	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.34: Summary statistics of prices under demand shock secarios 8-10

Constant in regional natural gas demand function decreases by 25% for:						
	Europe		Middle East		America	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Crude oil price, Brent (2005 US$/bbl)						
	70.5065 ***	0.0000	70.5065 ***	0.0000	70.5065 ***	0.0000
(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	
	[0.0000]		[0.0000]		[0.0000]	
Regional natural gas price (2005 US$/mmbtu)						
Africa	8.5445 ***	2.6392 ***	8.5233 ***	2.6543 ***	8.5233 ***	2.6497 ***
	(0.0348)	(0.0196)	(0.0364)	(0.0206)	(0.0396)	(0.0227)
	[0.0141]		[-0.0071]		[-0.0071]	
Asia & Oceania	12.3662 ***	5.1594 ***	12.3773 ***	5.1483 ***	12.1835 ***	5.1925 ***
	(0.2072)	(0.0189)	(0.2193)	(0.0177)	(0.2213)	(0.0196)
	[0.2104]		[0.2214]		[0.0277]	
Eurasia	2.0695 ***	0.1653 ***	2.0737 ***	0.1550 ***	2.1022 ***	0.0853 *
	(0.0143)	(0.0350)	(0.0153)	(0.0375)	(0.0158)	(0.0388)
	[-0.0180]		[-0.0139]		[0.0146]	
Europe	6.1815 ***	2.3596 ***	6.2071 ***	2.5491 ***	6.1367 ***	2.2814 ***
	(0.0624)	(0.1374)	(0.0658)	(0.1339)	(0.0664)	(0.1406)
	[-0.0960] *		[-0.0704]		[-0.1409] **	
Middle East	11.0913 ***	4.7487 ***	11.0695 ***	4.7831 ***	11.0206 ***	4.8200 ***
	(0.1007)	(0.0541)	(0.1174)	(0.0606)	(0.1117)	(0.0573)
	[-0.0326]		[-0.0543]		[-0.1032]	
America	9.5894 ***	2.7764 ***	9.6460 ***	2.6376 ***	9.6989 ***	2.5080 ***
	(0.0462)	(0.1132)	(0.0514)	(0.1258)	(0.0526)	(0.1290)
	[-0.0945] **		[-0.0378]		[0.0151]	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.35: Summary statistics of prices under demand shock secarios 11-13

Constant in regional natural gas demand function increases by 25% for:						
	Africa		Asia & Oceania		Eurasia	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Crude oil price, Brent (2005 US$/bbl)						
	70.5065 ***	0.0000	70.5065 ***	0.0000	70.5065 ***	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	[0.0000]		[0.0000]		[0.0000]	
Regional natural gas price (2005 US$/mmbtu)						
Africa	8.5445 ***	2.6359 ***	8.4738 ***	2.6769 ***	8.5339 ***	2.6441 ***
	(0.0389)	(0.0220)	(0.0434)	(0.0246)	(0.0350)	(0.0199)
	[0.0141]		[-0.0566] *		[0.0035]	
Asia & Oceania	12.4326 ***	5.1727 ***	11.9455 ***	5.1899 ***	12.1503 ***	5.1900 ***
	(0.2297)	(0.0186)	(0.2131)	(0.0174)	(0.2237)	(0.0178)
	[0.2768]		[-0.2104]		[-0.0055]	
Eurasia	2.0850 ***	0.1275 ***	2.1083 ***	0.0704	2.0256 ***	0.2728 ***
	(0.0155)	(0.0379)	(0.0176)	(0.0432)	(0.0108)	(0.0264)
	[-0.0026]		[0.0207] *		[-0.0619] ***	
Europe	6.2263 ***	2.5356 ***	6.2391 ***	2.5699 ***	6.2804 ***	2.6682 ***
	(0.0739)	(0.1537)	(0.0676)	(0.1454)	(0.0718)	(0.1535)
	[-0.0512]		[-0.0384]		[0.0029]	
Middle East	11.0424 ***	4.7859 ***	11.2434 ***	4.6911 ***	11.1402 ***	4.7074 ***
	(0.1073)	(0.0608)	(0.1097)	(0.0504)	(0.1129)	(0.0654)
	[-0.0815]		[0.1195]		[0.0163]	
America	9.7367 ***	2.4154 ***	9.5894 ***	2.7764 ***	9.5894 ***	2.7764 ***
	(0.0603)	(0.1477)	(0.0454)	(0.1113)	(0.0563)	(0.1378)
	[0.0529]		[-0.0945] **		[-0.0945] *	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table B.36: Summary statistics of prices under demand shock secarios 14-16

Constant in regional natural gas demand function increases by 25% for:						
	Europe		Middle East		America	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Crude oil price, Brent (2005 US$/bbl)						
	70.5065 ***	0.0000	70.5065 ***	0.0000	70.5065 ***	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	[0.0000]		[0.0000]		[0.0000]	
Regional natural gas price (2005 US$/mmbtu)						
Africa	8.5409 ***	2.6444 ***	8.5339 ***	2.6444 ***	8.5374 ***	2.6435 ***
	(0.0373)	(0.0214)	(0.0406)	(0.0228)	(0.0388)	(0.0220)
	[0.0106]		[0.0035]		[0.0071]	
Asia & Oceania	12.1171 ***	5.2050 ***	12.1835 ***	5.2050 ***	12.3662 ***	5.2040 ***
	(0.2012)	(0.0213)	(0.2179)	(0.0200)	(0.2029)	(0.0183)
	[-0.0387]		[0.0277]		[0.2104]	
Eurasia	2.0685 ***	0.1679 ***	2.0864 ***	0.1238 **	2.0747 ***	0.1527 ***
	(0.0155)	(0.0380)	(0.0162)	(0.0397)	(0.0165)	(0.0403)
	[-0.0191]		[-0.0011]		[-0.0129]	
Europe	6.2519 ***	2.6359 ***	6.2263 ***	2.5385 ***	6.2125 ***	2.4787 ***
	(0.0737)	(0.1505)	(0.0738)	(0.1597)	(0.0609)	(0.1300)
	[-0.0256]		[-0.0512]		[-0.0650]	
Middle East	10.9772 ***	4.8629 ***	10.9663 ***	4.8202 ***	11.0424 ***	4.8189 ***
	(0.0964)	(0.0562)	(0.1112)	(0.0539)	(0.1034)	(0.0531)
	[-0.1467] *		[-0.1575] *		[-0.0815]	
America	9.5931 ***	2.7671 ***	9.5894 ***	2.7764 ***	9.6762 ***	2.5635 ***
	(0.0493)	(0.1207)	(0.0432)	(0.1057)	(0.0500)	(0.1224)
	[-0.0907] *		[-0.0945] **		[-0.0076]	

Notes: Standard errors in parentheses. Change from base-case simulation in square brackets, followed by significance stars indicating p-value from two-sample t-test of difference between counterfactual simulation and the base-case simulation. Significance codes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.