CAN A CARTEL FUEL THE ENGINE OF ECONOMIC DEVELOPMENT?

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Can a Cartel Fuel the Engine of Economic Development?

OPEC and the macroeconomics of oil

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Abstract

OPEC's stated mission is to promote the economic development and growth of its member states while minimizing volatility in the oil markets. But after a promising beginning many member states' economies have declined rather than prospered—a clear indication of OPEC's failure to meet their development goals. Thus, we ask if a resource cartel can achieve the joint goals of development and resource market stability. In a model in which oil producing countries choose whether to join an oil cartel or remain in the fringe, we find that, in a highly elastic oil market, a profit maximizing cartel is inconsistent with oil market stability in the face of demand shocks. Thus, it is inimical to macroeconomic stability, an essential requirement for long-lasting capital investment, and therefore economic development and growth. Consequently, it may not be optimal for an oil-exporting country that cares adequately about macroeconomic stability to join the cartel. But for a country where short-run considerations overwhelm long-run concerns, cartel membership may be the correct choice. Yet the oil rich are ultimately cursed by their excessive reliance on their resource wealth—current profligacy begets future decline.

JEL: E6, F4, Q43, Q32, O11
Keywords: OPEC, macroeconomic stability, resource curse, economic development

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Abstrakt

Misí OPECu je prosazovat a podporovat ekonomický vývoj a růst svých členských států a minimalizovat volatilitu na trhu ropných produktů. Po slibném začátku mnoho ekonomik členských států výkonnostně pokleslo spíše než prosperovalo, což je znamením selhání OPECu při plnění svých cílů. Z tohoto důvodu se ptáme jestli surovinový kartel může dosáhnout dvou společných cílů ekonomického vývoje a stability trhu zdrojů. V modelu, ve kterém země produkující ropu vybírají zda se přidají k ropnému kartelu či nikoli zjišťujeme, že na vysoce elastickém trhu ropy je kartel maximalizující zisk a vystavený poptávkovým šokům neslučitelný s tržní stabilitou. Proto je tento škodlivý pro makroekonomickou stabilitu jakožto základní požadavek pro dlouhotrvající kapitálové investice a tedy i ekonomický rozvoj a růst. Následně by pro zemi exportující ropu a přiměřeně se zaměřující na makroekonomickou stabilitu nemuselo být výhodné připojovat se ke kartelu. Na druhou stranu pro zemi, kde krátkodobé úvahy převáží nad těmi dlouhodobými, může být členství v kartelu dobrou volbou. Přesto jsou státy bohaté na ropu nakonec negativně ovlivněny svým přehnaným spoléháním se na své nerostné bohatství - současná rozmařilost působí budoucí ekonomický pokles.

INTRODUCTION

"OPEC is an international Organization of eleven developing countries which are heavily reliant on oil revenues as their main source of income. Membership is open to any country which is a substantial net exporter of oil and which shares the ideals of the Organization."

"Since oil revenues are so vital for the economic development of these nations, they aim to bring stability and harmony to the oil market by adjusting their oil output to help ensure a balance between supply and demand."

OPEC

OPEC was formed to promote economic development in its member countries and to minimize the volatility of oil markets. To accomplish these combined goals, the cartel uses its market power to sustain a high, stable price of oil to generate high, stable income for its members. Yet, the recent experience of most OPEC countries has not been one of relative prosperity but rather one of relative decline (Cordesman, 1999).

In this paper we ask a straightforward question—is it possible for OPEC to achieve its stated goals? That is, can the cartel provide an economic environment conducive to development and growth? Since the oil sector represents an important share of income for oil exporting, developing countries, instability in the oil market also means macroeconomic instability for those countries; thus, has OPEC been a useful tool to achieve oil market, and thus macroeconomic, stability? If the answer to these two questions is no, what is the rationale for OPEC to continue to exist? In other words, can oil exporting developing countries do better in terms of development by joining an oil cartel? If so, since all substantial oil exporters can choose to join, why do some important exporting countries like Mexico, Oman, Angola and, perhaps, Russia, whose production and development levels are similar to other countries in OPEC, choose to stay in the fringe? What induces countries like Ecuador to enter and then leave shortly thereafter? Why do Mexico, Russia, Egypt and Kazakhstan find membership inconsistent with their domestic macroeconomic policies if membership is, indeed, intended to jointly promote stability and economic development?

There are two important features of the international oil market worthy of mention. First, the OPEC cartel meets twice a year, in March and September, and in extraordinary sessions whenever it considers such sessions necessary. In those meetings, the cartel analyzes the state of the international oil market, and sets quotas for its member states (see www.opec.com). Thus, OPEC tries to move (preempt) the market rather than be moved by it. OPEC's production represents about 40% of total world oil production. Among non-OPEC producers, Russia's production is 12% of the world production, and no other country produces even 5% of the total. This means that the international oil market operates as a Stackleberg oligopoly where the OPEC cartel plays the role of the leader. Another important feature that distinguishes the oil cartel from most (if not all) other cartels is that governments, and not firms, make the decision about joining the cartel.

Taking these features as assumptions, we answer the above questions in the context of a simple model in which oil producing countries choose either to join OPEC or remain part of the fringe. Equilibrium is stable and thus the cartel members have no temptation to cheat. OPEC acts as a Stackleberg leader, and reacts to market shocks by setting the output quotas for its members. We find that if oil producing countries only care about high oil sector profits, then joining the cartel is the optimal strategy. But countries in the cartel will have more volatile oil production than those in the fringe and thus, higher macroeconomic instability. Therefore, if these same governments care about macroeconomic stability as well as oil sector profits, then the choice to join the cartel will depend on the intensity of this preference: the more a producer cares about macroeconomic stability, the less inclined it is to be a cartel member. Thus, if an oil producing country cares about both oil industry profits and macroeconomic stability, the goal of macroeconomic stability may be inconsistent with cartel membership.

The paper proceeds as follows. We first provide a brief discussion of the economic performance of the OPEC member states, and examine OPEC's ability to influence the oil market. We then examine how OPEC's objectives—as specified in its mission statement—could be operationalized, write down a model of the cartel and analyze its behavior. Finally, we summarize and interpret our results.

I. The OPEC Economies

OPEC was established in 1960 to take sovereign control over oil resources, and to ensure that the interests of oil producing countries would be well represented in the world markets. The founding members of OPEC felt that their economies were at the mercy of the oil companies, and that they were not being adequately compensated for the oil the companies were extracting, exporting, and refining. By design, OPEC was to establish orderly oil markets, stable prices, and promote the economic development of its member states. OPEC's mission differentiates it from a narrowly defined cartel under which joint profits are maximized. That OPEC does not behave strictly like a narrowly defined cartel has been found by Griffin (1985), Griffin and Xiong (1997), and Loderer (1985), among others. Their results could be explained, in part, by OPEC's broader goals.

In comparison with other developing economies, the immensely oil rich economies have underperformed. Their economies are characterized by very high population growth rates and high rates of oil dependence both in terms of personal income and public finance. High extraction rates have led to falling oil reserves. In many OPEC member countries, investment, even in the oil sector, is low. Cordesman (1999) argues that many oil states do not even have the resources to develop their own oil and gas reserves. Yet because of the high level of oil dependence, the oil sector must perform well both to maintain current and ensure future living standards (Morrison, 2004). But, oil sector and overall economic productivity in the OPEC economies has declined, and today less rather than more is being produced with the same resources.

This economic decline has been interpreted by some as evidence that the OPEC economies have been victims of the resource curse (Auty, 2001; Eastwood and Venables 1982; Gylfason, 2001; Rodriguez and Sachs, 1999; Sachs and Warner, 2001; Stevens, 2004), the apparently anomalous empirical finding that many resource rich countries under-perform their resource poor peers. The reasons given for the curse are many: decline in the terms of trade, revenue volatility, the Dutch disease, crowding out, government mismanagement, rent seeking, corruption, etc. But, the end result is the same—relative poverty in the midst of plenty.

We suggest, in contrast, that some of the blame for the economic decline may lie in the cartel rather than in the resources it allocates. While OPEC, at least in principle, adjusts supply to maintain targeted (nominal) oil prices to maximize oil firm profits, it has not been able to control the market adequately to ensure a steady stream of oil derived revenues: it has been unable to provide for both consumption today and investment to ensure consumption tomorrow. For example, Venezuela's public sector oil revenues were 27 percent of GDP in 1996 but only 12.5 percent in 1998 (Barnett and Ossowski, 2003). The orderly market, the supposed empirical manifestation of a profit oriented pricing policy, is claimed to be a reality (Jalali-Naini and Asali, 2004), but the implied real benefits to OPEC members are more like fiction. The tension is this: In a highly price-elastic oil market, if OPEC adjusts output to sustain high oil prices, cartel members will receive a short-term windfall gain. But the effect of this course of action is short-run macroeconomic fluctuations and world economic slowdown, and thus diminished rather than enhanced long-run macroeconomic growth prospects. This is as true today as it was in the 1970s. When OPEC was founded in the early 1960s, the oil market was quite stable and the cartel strategy could work. Yet, with the high oil market volatility from the 1970s on, the dual OPEC goals of long-term growth and development may not be achievable by a profit-oriented pricing policy.

II. Market Equilibrium When Stability Does Not Matter

Assumptions

There is a continuum of petroleum producing countries distributed along the interval $(1, N)$.[1] These oil industries are controlled by their governments.

There is a cartel of oil producers which governments can freely choose to join. Assume n_c countries belong to the cartel while $n_f = N - n_c$ do not and remain in the fringe. Since oil output in each country is determined by the number of wells drilled and the amount of oil underground, it is reasonable to assume that each country's petroleum industry exhibits constant returns to scale technology and has the same cost

[1] We assume the continuum modeling for analytical ease. This formulation enables us to avoid concentrating attention on corner solutions that have no economic interest.

function, $C = C(x_{ti})$, where x_{ti} is country i's petroleum production at period t. This means that oil production has constant marginal costs. Oil prices are set according to the demand function $P_t = f(Q_t) + \varepsilon_t$, where $f' < 0$ and $f'' > 0$, Q_t denotes the world oil production and ε_t is a random term whose expected value is zero and variance is equal to σ_ε^2. The profit function for the petroleum industry at time t in country i is $\pi_{ti} = P_t x_{ti} - C(x_{ti})$, $i \in (1, N)$. Suppose, initially, that profits are the only concern; thus, the country's maximization problem is

(1) $$\text{Max} \sum_{t=0}^{\infty} \frac{1}{(1+r)^t} \pi_{ti} .$$

Assume that shocks are known before oil producers make output decisions, however, future shocks are unknown.

The Fringe

Firm f in the fringe takes the output of all other petroleum producers as given and maximizes (1) to determine its own output. The first order condition for a country in the fringe is

(2) $$f(Q_t^*) + \varepsilon_t + f'(Q_t^*) x_{tf}^* - C'(x_{tf}^*) = 0 ,$$

where the superscript "*" denotes the optimum choice. The second-order condition is:

(3) $$2f'(Q_t^*) + f''(Q_t^*) x_{tf}^* - C''(x_{tf}^*) < 0 \qquad \text{(to be maximum).}$$

Solving (2), we obtain the follower's reaction function (country *f*) to the cartel's move:

(4) $$x_{tf}^* = \phi^f (K_t^*, \varepsilon_t),$$

where $K_t^* = \sum_{c=1}^{n_c} x_{tc}^*$ is the cartel's oil production in period t. Using (2), we obtain the partial derivative of x_{tf} with respect to K_t and denote it by ϕ_c^f, that is,

(5) $$\phi_c^f = \frac{\partial \phi^f}{\partial K_t} = -\frac{f'(Q_t^*) + x_{tf}^* f''(Q_t^*)}{2f'(Q_t^*) + x_{tf}^* f''(Q_t^*) - C''(x_{tf}^*)}.$$

From (3), the denominator is negative, thus

$$\phi_c^f < 0 \qquad \text{if and only if} \qquad f'(Q_t^*) + x_f^* f''(Q_t^*) < 0 .$$

When reaction functions are upward sloping, $\phi_c^f > 0$, there is a situation in which followers copy or undercut the leader like, for example, entrants undercutting the price of the incumbent in the contestable market literature (Baumol, 1982) or followers in the development stage that invest more than the leader and are thus more likely to collect a patent in a research and development game (Reinganum, 1985). On the other hand, when reaction functions are downward sloping, $\phi_c^f < 0$, the leader makes a preemptive move, like an incumbent firm that invests in excess supply (Spence, 1979; Dixit, 1980). OPEC's operating procedure, semiannual plus extraordinary meetings, is to preempt the market.

The Cartel

For the sake of simplicity, assume that countries on the interval (1, n_c] are in the cartel and countries on the interval (n_c, N] are in the fringe. The leader takes into account the follower's reaction function (4), so it chooses x_{ti} for each cartel member to maximize

$$V_i = E_t \sum_{s=t}^{\infty} \beta_i^s \left[f(Q_s)K_s + \varepsilon_s K_s - \int_{c=1}^{n} C(x_{sc}) \right].$$

Since $Q_s = K_s + n_f \phi^f$, the first order condition for every country c in the cartel is:

(6) $$f(Q_t^*) + \varepsilon_t + K_t^*(1 + n_f \phi_c^f) f'(Q_t^*) - C'(x_{tc}^*) = 0 .$$

Since all countries are equal except for their membership in the cartel, we may consider symmetric equilibria, so x_{tc} is the same for every cartel member and x_{tf} is the same for every country in the fringe.

Theorem 1: Suppose that the slope of the reaction function ϕ_c^f is continuous, monotonic and well-defined for $1 < n_c \leq N$; then there is a Nash equilibrium with cartel size equal to n_c^* and the number of countries in the fringe equal to $n_f^* = N - n_c^*$ such that $\phi_c^f = \frac{1-n_c^*}{n_c^*\left(N-n_c^*\right)}$. In that Nash equilibrium, each country in the cartel produces the same amount of oil and obtains the same profit as a country in the fringe, $x^* = x_c^* = x_f^*$. That is, $x_c \geq x_f$ if and only if $\pi_c \geq \pi_f$.

Proof: See Appendix

To illustrate the theorem, consider Figure 1, where for the sake of simplicity, we have assumed that ϕ_c^f is constant. Although the assumption made in Theorem 1 about ϕ_c^f is more general, it is noteworthy that ϕ_c^f is constant if the demand function is linear and oil exploitation technology is constant returns to scale.

Define $B(n_c) = \frac{1-n_c}{n_c(N-n_c)}$ and n_c^* as the size of the cartel such that $B(n_c^*) = \phi_c^f$.

If the cartel size is greater than n_c^*, the cartel's market power is strong but each cartel member produces $x_c^* < x_f^*$. Once the cartel sets the quotas to target some price level, it is optimal for cartel members to cheat, that is, to imitate producers in the fringe and thus increase their production. The cartel's market power weakens and cheating countries do not benefit from belonging to the cartel. If cartel members are subject to some cost, like bargaining costs or moral punishments, they are better off if they quit. On the other hand, if the cartel size is less than n_c^*, then $x_c^* > x_f^*$ and profits are higher for cartel members. Producers in the fringe will find it optimal to join the cartel to gain from its market power. A Nash equilibrium is reached once the cartel has reached its optimal size n_c^* where cartel members have no incentive to cheat since equilibrium output and profit is the same for countries both in the cartel and the fringe. Therefore, the cartel solution is stable.

III. Market Equilibrium When Stability Matters

In the previous section's analysis, we assume that decision makers only care about the oil firm profits, and find a cartel size which constitutes a Nash equilibrium where there is no temptation to cheat. In practice, however, governments make the decision about joining the oil cartel. Thus, if membership in the cartel means more unstable production, a developing oil-exporting country's government that cares about the oil production stability, and hence macroeconomic stability, may decide to quit the cartel. Yet, why may a government give weight to oil output stability in their objective function? There are several reasons.

First, the OPEC charter states that the cartel countries care not only about profits from the oil industry, but also about creating an appropriate environment for investment and growth. Therefore, macroeconomic stability must be an issue.

Second, when access to international capital markets is imperfect, countries face a trade-off between higher oil profits and macroeconomic stability. To illustrate this, let $W = \sum_{i=0}^{\infty} U\left(C_{t+i}\right)$ be the inter-temporal utility function of country *i*'s representative agent, which is subject to a budget constraint like $C_t + B_t = Y_t + \left(1 + r\right)B_{t-1}$, where B_t is bonds, Y_t is output and r is the real interest rate. Under reasonable functional assumptions, welfare is optimized along the consumption smoothing path $C_t = C_{t-1} = C$. In this situation, individuals borrow when the oil market is down and vice versa. Yet, if the country has no access to international capital markets, its local financial institutions are weak, and/or it suffers from strong political business cycle problems, which is the usual case in emerging markets (Jeanne 2003, Litan *et al.* 2003 and Sy 2003), the consumption smoothing path may not be feasible anymore, and the solution to the maximization problem becomes $C_t = Y_t$, that is, consumption follows the cycle. Therefore, although joining the cartel may provide a higher average income to the typical oil exporting country, it may also generate more macroeconomic instability, which diminishes welfare. Therefore, the government faces a trade-off between having higher income and macroeconomic stability.

Third, for the typical oil-exporting developing country, stability in the number of barrels produced also provides more stability to the oil industry's local suppliers making investment in those related sectors less risky, and thus helping the development of areas in which the country should have natural comparative advantages. Finally, every time the oil industry (plus its multiplier effect) adjusts output, it lays off workers. Thus, a government that cares about employment stability should worry about stabilizing the number of barrels it produces.

Therefore, since the cartel implicitly determines the output level at which profits and thus income are maximized by setting the number of barrels extracted, it is reasonable to define the following objective function for a government that cares about both firm's profit and oil output stability:

$$V_{it} = E_t \sum_{s=t}^{\infty} \beta_i^s \left[\pi_{is} - \delta_i \left(x_{i,s-1} - \overline{x}_i \right)^2 \right].$$

Here β_i is the time-preference parameter for country *i*, π_{is} is the oil firms' profit, the term $\left(x_{i,s-1} - \overline{x}_i \right)^2$ accounts for the loss due to the instability in the oil production (a proxy for the variance of the GDP gap), and δ_i is the weight that the government gives to output instability in the objective function. With this objective function, equations (2) and (6) become:

(7a) $f\left(Q_t^*\right)+\varepsilon_t+f'\left(Q_t^*\right)x_{tf}^*-C'\left(x_{tf}^*\right)=2\beta_f\delta_f\left(x_{tf}^*-\overline{x}_f\right)$ and

(7b) $f\left(Q_t^*\right)+\varepsilon_t+K_t^*\left(1+n_f\phi_c^f\right)f'\left(Q_t^*\right)-C'\left(x_{tc}^*\right)=2\beta_c\delta_c\left(x_{tc}^*-\overline{x}_c^*\right)$,

where $\overline{x}_i$ and $\overline{\pi}_i$ denote country *i*'s optimal oil production and the profits of the oil industry in steady state equilibrium, respectively.

Theorem 2: When the government values oil sector stability, then:

i) the following three statements are equivalent:

(a) $\overline{x}_c \geq \overline{x}_f$, (b) $\overline{\pi}_c \geq \overline{\pi}_f$, and (c) $\phi_c^f \leq \dfrac{1-n_c}{n_c\left(N-n_c\right)}$;

ii) given n_c^*, then $\overline{x_c}$ and $\overline{x_f}$, and thus $\overline{\pi_c}$ and $\overline{\pi_c}$ are independent of β and δ.

<u>Proof: See Appendix</u>

Theorem 3: i) Oil output is positively correlated across countries.

ii) The oil output variance is a decreasing function of the time preference parameter (β) and the spillover effect on the non-oil sector (δ).

<u>Proof: See Appendix</u>

This means that, *ceteris paribus*, cartel and fringe producers respond to a positive demand shock by increasing output. It also means that volatility in oil production decreases the higher the time preference parameter (higher β), and the stronger the spillover effect of oil production volatility on the non-oil sector (higher δ). Thus, care for macroeconomic stability reduces countries' willingness to accept a highly variable production quota. These facts may induce governments to change their decision about joining the cartel.

Theorem 4: Assume that oil production exhibits constant returns to scale, that the reaction functions are negatively sloped, and that $\delta > 0$. Consider two identical producers except that one belongs to the cartel and the other is in the fringe, then:

(i) the oil output variance is higher for a producer in the cartel than the identical producer in the fringe $\sigma_c^2 - \sigma_f^2 > 0$;

(ii) the difference $\sigma_c^2 - \sigma_f^2$ is a decreasing function of β and δ; and

(iii) the difference between the average profit for the producer in the cartel and the producer in the fringe, $\overline{\pi}_c - \overline{\pi}_f$, decreases as the cartel size increases.

Proof: See Appendix

The intuition behind this result is that the cartel uses its higher market power to obtain a higher profit as it faces a demand shock. That gain is lower the more a country cares for macroeconomic stability.

Consider a country deciding whether or not to join the cartel from period *t* on. The expected profit of the oil industry is $\overline{\pi}_c$ if it joins the cartel, or $\overline{\pi}_f$ if it stays in the fringe. Country *i*'s objective function can be written as

$$V_i = \frac{1}{1-\beta_i}\left[\overline{\pi}_i - \delta_i \sigma_i^2(\beta_i, \delta_i)\right].$$

Let V_c denote the country's net gain if it joins the cartel and V_f if it stays in the fringe. Country *i* joins the cartel if $V_c > V_f$, that is, if

(8) $\overline{\pi}_c - \overline{\pi}_f > Z(\beta, \delta),$

where $Z(\beta,\delta)=\delta\left[\sigma_c^2(\beta,\delta)-\sigma_f^2(\beta,\delta)\right]$. The term $\left(\bar{\pi}_c-\bar{\pi}_f\right)$ measures the gain in expected profits and $Z(\beta,\delta)$ measures the loss due in macroeconomic instability if the country is in the cartel instead of in the fringe. From Theorem 4, the difference $\left(\bar{\pi}_c-\bar{\pi}_f\right)$ is a decreasing function of n_c that cuts the axis at $n_c=n_c^*$, as shown in Figure 2. The number of countries that join the cartel depends on the countries' distribution across the parameters β and δ.

To get some insights, define the index set for the N countries in such a way that $Z(\beta_i,\delta_i)$ is a continuous increasing function of $i\in(0,N)$. From Figure 2, we observe that inequality (8) holds for the first n_c^{**} countries; those with $i<n_c^{**}$ join the cartel, and the other $n_f^{**}=N-n_c^{**}$ remain in the fringe. From Theorem 4(ii), $Z(\beta,\delta)\geq 0$, and thus there exists an equilibrium in which some producers join the cartel and some others decide to stay in the fringe. If $\delta = 0$, then $Z(\beta,\delta)=0$ and equilibrium is reached when the cartel size equals n_c^* as in Theorem 1. Yet, if $\delta > 0$, equilibrium is reached for a cartel size equal to n_c^{**} smaller than n_c^*, that is, the cartel size is smaller when some countries care for macroeconomic stabilization than in the special case when stabilization does not matter.

The dynamic of the cartel in this model can be seen as a repeated game, where players are free to choose the strategy of whether or not to join the cartel; they are free to "cheat" and condition (8) defines equilibrium. Consider a country that joins the cartel, so (8) holds. If the country imitates the fringe's behavior, it is not punished, but its loss in terms of profits is too high since it does not maximize (1) and thus it will be worse off: the cartel is internally stable. Similarly, a country in the fringe will not want to imitate a country in the cartel since the cost in macroeconomic instability is too high.

Therefore, a country joins the cartel if it is committed to keep its quota, and thus the cartel solution defined by (8) is a stable equilibrium.[2]

What are the features of those countries that join the cartel? Given δ, from Theorem 4(ii), $\sigma_c^2 - \sigma_f^2$ is a decreasing function of time-preference factor β. Therefore, countries with a low time-preference factor β, which have a strong preference for current consumption and low investment-output ratios, give little importance to future losses due to macroeconomic instability, and so $Z(\beta,\delta)$ is small. For them, inequality (8) holds. They are likely to join the cartel.

The analysis of the parameter δ requires a more detailed analysis. Given β, since $\sigma_c^2 - \sigma_f^2$ is a decreasing function of δ, $Z(\beta,\delta)$ has the shape shown in Figure 3(a). Thus, countries with either low δ $(< \delta_1)$ or very high δ $(> \delta_2)$ join the cartel. If δ is low, either the impact of oil output instability on the non-oil sector is low or the non-oil sector is rather small. This could be the case in countries whose non-oil sector is highly rural. These countries put a priority on the well-being of their oil industry and join the cartel. On the other hand, countries with a very high δ have much to lose from spillover effects that instability in oil production cause in the non-oil sector, and will join the cartel only if their quota is insensitive to demand shocks, diminishing the instability effect.

Finally, let us consider the effect of market volatility on the cartel size. It is apparent that $Z(\beta,\delta)$ is a decreasing function of the variance of ε; thus, if the oil market is very unstable, the variance of ε is big, and equilibrium will be as shown in Figure 3(a), where some countries find it beneficial to join the cartel and others do not. Yet, if

[2] Here we follow the definition of a stable cartel as suggested in D'Aspremont *et al.* (1983), Donsimoni *et al.* (1986), Jacquemin and Slade (1989) and Marette and Crespi (2003).

market volatility is low and the variance of ε is too small, $Z(\beta, \delta)$ will be as shown in Figure 3(b), and all countries join the cartel.

IV. Conclusions

A distinguishing feature of the international oil market is that the decision about joining the OPEC cartel is not taken by firms, but by governments that take macroeconomic considerations, namely development and stabilization, into account. This essay studies the issue of whether the cartel has been a useful tool for those purposes in the context of a Stackleberg type model in which oil exporting, developing countries decide whether or not to join the cartel. The model leads to four important conclusions. The first is that countries with a strong preference for current consumption join the cartel. The reasons for this preference may vary across countries: in Kuwait, for instance, it may be due to the high population growth rate (4.9% annually during the last 10 years), while in Iraq it may have been due to the need for current income to finance several wars during Saddam's regime. A strong preference for current consumption (low β) is reflected in relatively low investment/output ratios and poor economic performance in terms of long term per capita output growth. This could account for the economic performance in countries (see Table 1) like Kuwait, Iraq, Libya, Nigeria, Saudi Arabia or Venezuela, whose investment/output ratios have been less than 20% during the last decade. The decision to join the cartel and the exigencies of cartel, as opposed to macroeconomic, stability has cursed rather than blessed them.

Second, countries whose non-oil sectors either show low vulnerability to the variance in oil production or are small relative to the oil sector will also join the cartel. This would be the case, for example, for countries with a large rural sector, such as Iran where the agricultural sector represents over 20% of the GDP. Yet not only countries with low vulnerability to the oil output variance will join the cartel. There is a third reason. Since the oil-output variance is a source of macroeconomic instability, countries with very large non-oil sectors or that are highly vulnerable to the oil output variance (high δ) are better off enjoying cartel prices and at the same time having low oil-output variances. Therefore, if their quotas exhibit low variances, it would be beneficial for them to join the cartel. This could explain Indonesia's, and to a lesser extent Iran's, OPEC membership, since their oil production to GDP ratios are small and the correlations between their oil production and the cartel's are rather low. Finally, we conclude that all oil exporting countries would find it beneficial to join the cartel if the volatility of the oil market were low. This could explain why, for example, when OPEC was set up in the early 1960s, all important oil exporters at that time joined the cartel, and why many of these countries enjoyed high growth rates during the 1960s. The case of Venezuela exemplifies this. After enjoying an average growth rate above 5% per year between 1945 and 1973, one of the highest growth rates in the world, its average growth rate from 1978 on, just after the oil market volatility became a serious concern for producing countries, has been close to zero.

What about the countries in the fringe? A glance at Table 2 shows that all producers whose oil exports are less than 600 thousand barrels per day are in the fringe. However, except for Denmark, oil production is still an important share of their GDPs. Thus, they can take advantage of oil industry windfalls generated by the cartel's leadership role without being members of the cartel. But, this is at the recognized cost of letting their non-oil sector suffer the swings of the oil market. This could be also the case for Russia, Mexico and Angola, whose oil output variances are moderately correlated with OPEC.

The reader may wonder at this point why highly industrialized countries, whose non-oil sectors are very large and highly vulnerable to the swings of the oil market (high δ), do not join the cartel. For these countries, oil is an important input and high oil prices have an important negative effect on their economic growth rates. Therefore, they will always avoid joining a cartel.[3] We do not include this effect in the model since it is not important when dealing with oil-dependent developing economies. In fact, a typical feature of oil exporting developing economies is that energy is quite cheap because of excess supply, or, most often, because its energy sector is highly subsidized. This is definitely not the case for Canada, Norway or the U.K.

Is OPEC an appropriate tool to foster economic development? In an oil market with low volatility, like that prevailing before the 1970s, oil exporting countries may enjoy a high flow of financial resources and enough macroeconomic stability to foster investment and development; this could also be the case of countries like Indonesia, whose oil sector enjoys the advantages of cartel prices, but has a low variance quota inside the cartel that benefits its large non-oil sector. Yet, this is not the case in the volatile oil market of today, where the non-oil sectors of OPEC countries are hindered because of its hunger for current profits. For them, current profligacy begets future decline.

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[3] Harkness (1984) and Garratt *et al.* (2003) explore the macroeconomic consequences for oil exporting industrialized economies.

TABLE 1
SOME STATISTICS ON OPEC COUNTRIES 1993–2002

	Average. exports (thousands barrels per day) (1)	Correlation with OPEC exports	Per Capita Growth (%) (2)	Ratio Oil Output / GDP (%) (2)	Share of Oil on Exports (%) (3)	Share of Oil on Tax Revenues (%) (3)	Ratio Investment / GDP (%) (3)	Population Growth (%) (2)
Algeria	1,214	0.51	0.45	31.3	96.8	64.6	15.8	1.8
Indonesia	629	-0.17	2.40	8.8	21.8	25.0	25.0	1.4
Iran	2,472	0.01	2.29	7.9	80.8	52.6	24.9	1.5
Iraq (4)	1,052	0.78	-1.16	--	95.0	--	--	2.4
Kuwait	1,876	0.23	0.16	46.7	91.8	64.8	13.6	4.9
Libya	1,237	0.19	-0.92	--	93.7	59.6	12.8	1.9
Nigeria	1,815	0.90	-0.52	41.0	96.0	20.9	19.9	2.7
Qatar (4)	649	0.76	--	55.0	85.0	70.0	--	2.0
Saudi Arabia	7,686	0.18	-0.81	45.0	90.0	75.0	19.1	2.7
U. Arab Emirates	2,108	0.87	-0.17	23.5	48.7	63.9	--	4.3
Venezuela	2,662	0.88	-1.58	26.1	82.2	55.4	17.3	2.1

Source:
(1) USA Department of Energy;
(2) World Bank;
(3) IMF Country Reports;
(4) CIA World Factbook

Note: All statistics show the average between 1998 and 2002, except for average exports, which is between 1992 and 2002.

TABLE 2
NON-OPEC EXPORTS AND CORRELATION WITH OPEC PRODUCTION
PERIOD 1993–2002

	Average exports thousands of barrels per day	Correlation with OPEC exports
Russia	3,746	0.31
Norway	2,880	0.68
Mexico	1,446	0.51
United Kingdom	906	0.47
Oman	837	0.85
Canada	673	0.51
Angola	667	0.50
Egypt	377	-0.52
Colombia	369	0.75
Kazakhstan	354	0.43
Argentina	342	0.61
Gabon	312	0.07
Malaysia	310	0.22
Syria	310	-0.53
Yemen	300	0.65
Ecuador	259	-0.02
Congo (Brazzaville)	227	0.87
Brunei	177	0.53
Trinidad and Tobago	110	-0.63
Vietnam	101	0.56
Azerbaijan	89	0.51
Equatorial Guinea	82	0.51
Cameroon	81	-0.21
Papua New Guinea	74	-0.60
Turkmenistan	60	0.54
Denmark	46	0.47
Sudan	36	0.36
Bahrain	24	-0.35

Source: USA Department of Energy

FIGURE 1

THE SIZE OF THE CARTEL WHEN STABILITY DOES NOT MATTER

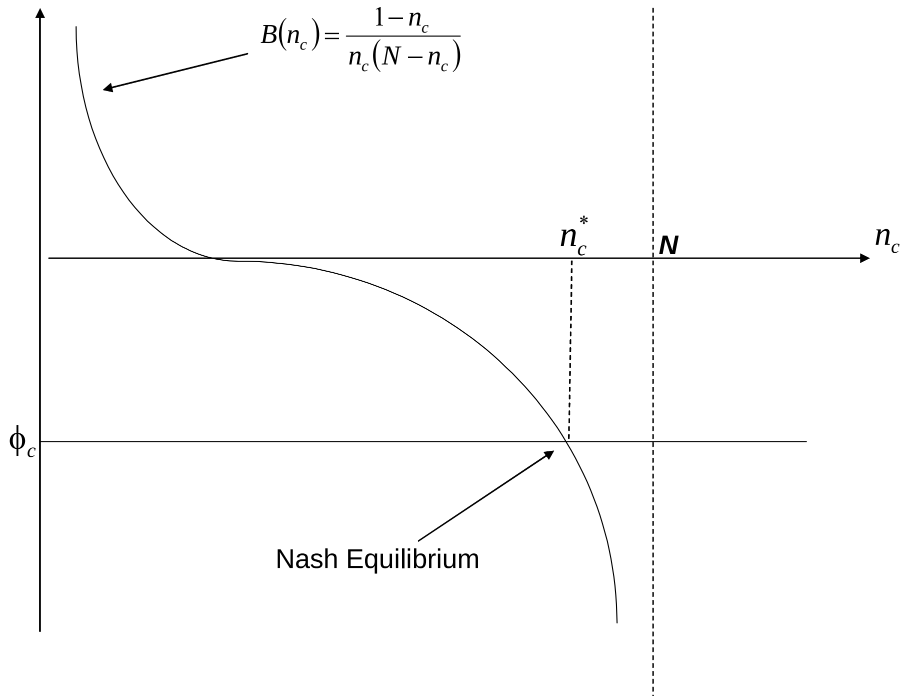


FIGURE 2

EQUILIBRIUM CARTEL SIZE

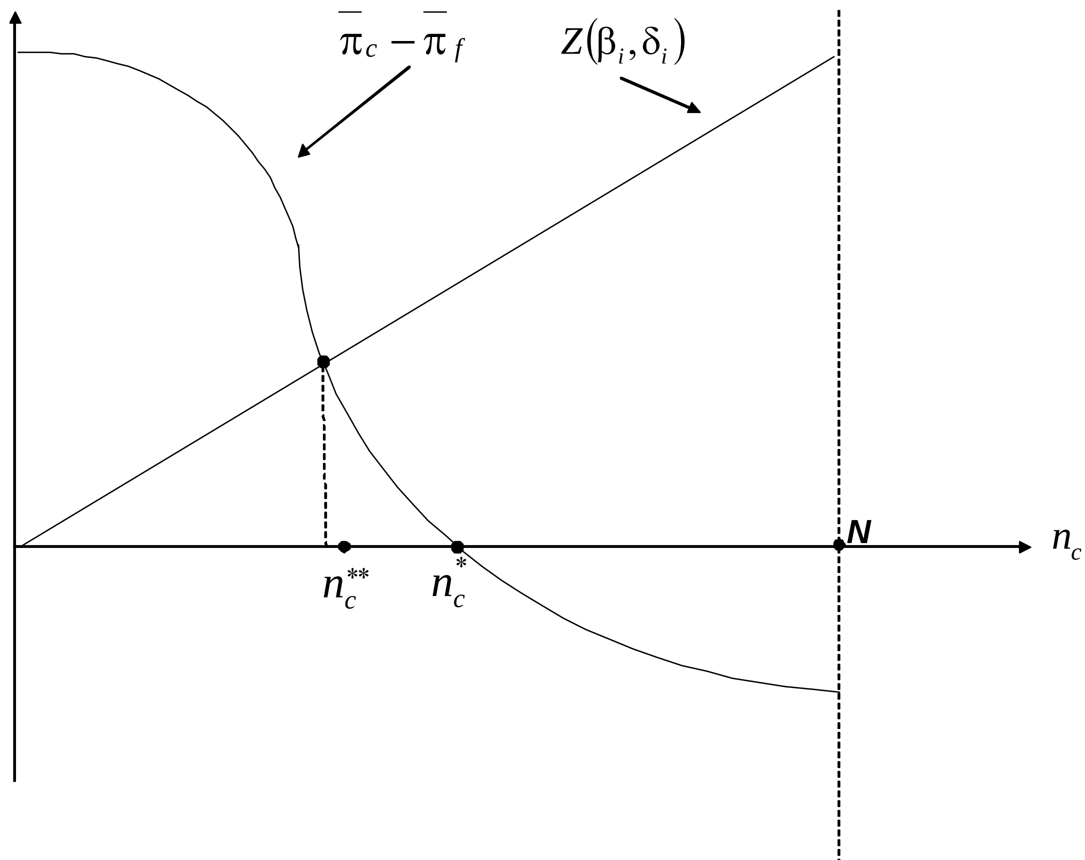
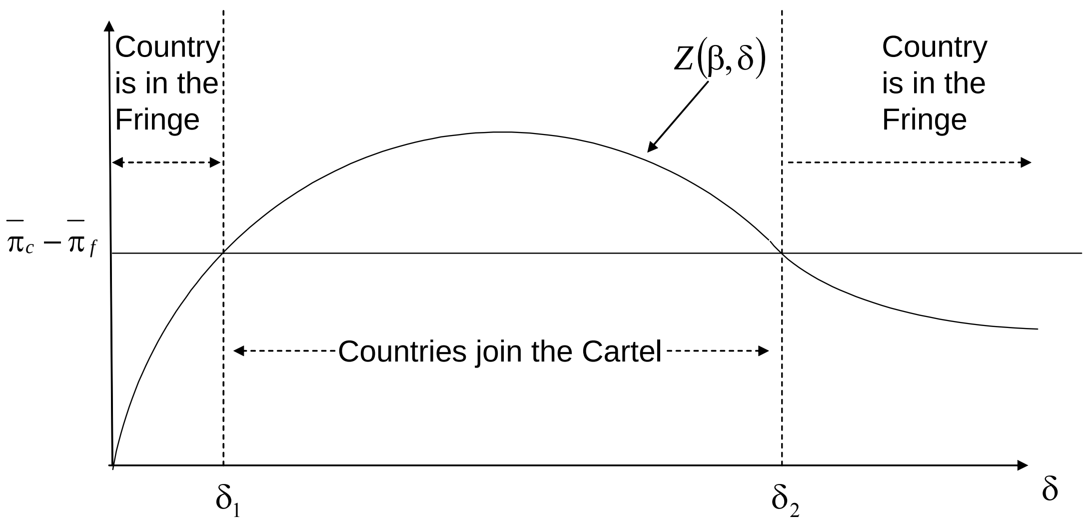


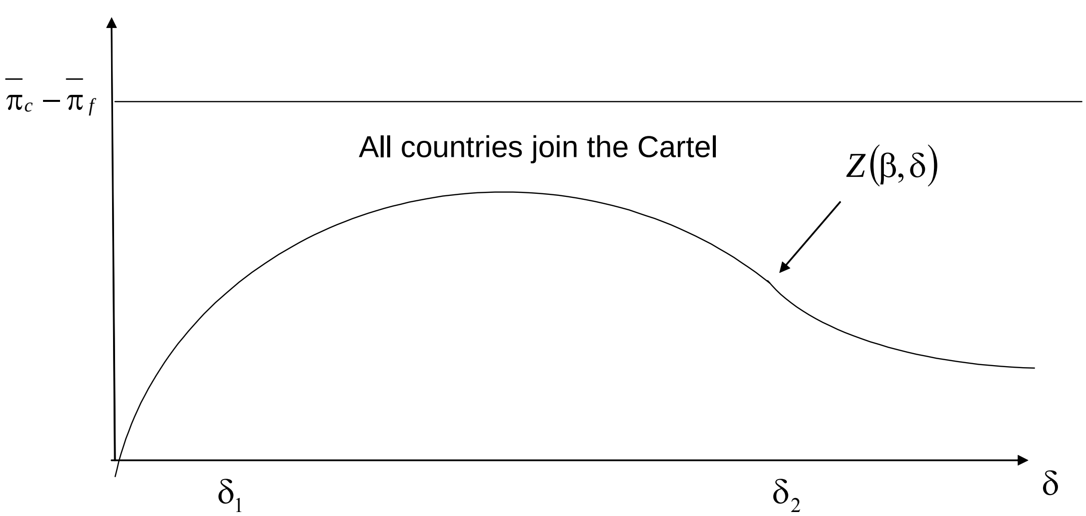
FIGURE 3

EQUILIBRIUM CARTEL SIZE

(a) Equilibrium When the Output Variance is High



(b) Equilibrium When the Output Variance is Low



Appendix

<u>Proof of Theorem 1</u>: Let us first prove that $\phi_c^f \leq \frac{1-n_c}{n_c(N-n_c)}$ if and only if $x_c^* \geq x_f^*$.

Consider the profit function, $\pi = \left(f\left(Q^T\right)+\varepsilon\right)x - C(x)$. Suppose that one country decided to change its own output without consulting the cartel, then

(A1) $\quad \pi'(x) = f\left(Q^T\right)+\varepsilon + f'\left(Q^T\right)x - C'(x)$.

From (2), π reaches a maximum at x_f^*, and thus (A1) equals zero; therefore $\pi'\left(x_f^*\right)=0$, and $x_c^* \geq x_f^*$ if and only if $0 = \pi'\left(x_f^*\right) \geq \pi'\left(x_c^*\right)$. Using (A1) and (6), this occurs if and only if $f+\varepsilon+n_c x_c^* f'\left(1+n_f\phi_c\right) - C'\left(x_c^*\right) = 0 \leq f+\varepsilon+f' x_c^* - C'\left(x_c^*\right)$. With a bit of algebra and rearranging, we have $\phi_c^f \leq \frac{1-n_c}{n_c(N-n_c)}$.

We now prove the equivalence between $x_c^* \geq x_f^*$ and $\pi\left(x_c^*\right) \geq \pi\left(x_f^*\right)$. Consider the profit function $\pi = \left(f\left(Q^T\right)+\varepsilon\right)x - C(x)$. From the mean value Theorem, there exists x^n between x_c^* and x_f^* such that $\pi\left(x_c^*\right) - \pi\left(x_f^*\right) = \left(x_c^* - x_f^*\right)\pi'\left(x^n\right)$. Therefore,

(A2) $\quad \pi\left(x_c^*\right) - \pi\left(x_f^*\right) = \left(x_c^* - x_f^*\right)\left(f\left(Q^T\right)+\varepsilon - C'\left(x^n\right)\right)$.

Yet, $\pi'(x) = f\left(Q^T\right)+\varepsilon - C'(x)$ is the difference between price and marginal cost. If x_{ce} is the competitive equilibrium, then $\pi'\left(x_{ce}\right)=0$, but in this case all firms have market power and so, $\pi'\left(x_c^*\right)>0$ and $\pi'\left(x_f^*\right)>0$. Since x^n is between x_c^* and x_f^*, it must be that $\pi'\left(x^n\right)>0$ is positive and so:

$$\pi\left(x_c^*\right) \geq \pi\left(x_f^*\right) \qquad \text{if and only if} \qquad x_c^* \geq x_f^*.$$

Therefore, if $\phi_c^f > \frac{1-n_c}{n_c(N-n_c)}$, profits for cartel members are greater than profits for producers in the fringe, and thus more countries want to join the cartel. On the other hand, if $\phi_c^f < \frac{1-n_c}{n_c(N-n_c)}$, cartel members have temptation to cheat and thus behave as

producers in the fringe. A Nash equilibrium is reached for n_c^* such that $\phi_c^f > \frac{1-n_c^*}{n_c^*(N-n_c^*)}$.

Q.E.D.

<u>Proof of Theorem 2</u>:

These statements follow from Theorem 1, since in this case ε_t = 0 and equations (7a) and (7b) reduce to (2) and (6).

Q.E.D.

<u>Proof of Theorem 3</u>: Consider the oil production volatility between cartel and non-cartel members. From (7a) and (7b) we have

(A3) $$\frac{\partial x_{tf}^*}{\partial \varepsilon_t} = \frac{-1}{2f'(Q_t) + f''(Q_t)x_{tf}^* - C''(x_{tf}^*) - 2\beta_f\delta_f}$$

and

(A4)

$$\frac{\partial x_{tc}^*}{\partial \varepsilon_t} = \frac{-1}{f'(Q_t) + K_t(1+n_f\phi_c^f)f''(Q_t) + \left[K_t n_f \phi_{cc}^f + n_c(1+n_f\phi_c^f)\right]f'(Q_t) - C''(x_{tc}^*) - 2\beta_c\delta_c}.$$

From the second order conditions for firms in the fringe and in the cartel respectively, the denominators are negative and thus both terms are positive. Thus, producers in both the cartel and the fringe respond similarly to demand shocks. This proves (3i). By taking cross derivatives on (A3) and (A4) with respect to βδ, we have

$$\frac{\partial^2 x_{tf}^*}{\partial \varepsilon_t \partial(\beta\delta)} = -2\left(2f'(Q_t) + f''(Q_t)x_{tf}^* - C''(x_{tf}^*) - 2\beta_f\delta_f\right)^{-2}$$ and

$$\frac{\partial^2 x_{tc}^*}{\partial \varepsilon_t \partial(\beta\delta)} = \frac{-2}{\left[f'(Q_t) + K_t(1+n_f\phi_c^f)f''(Q_t) + \left[K_t n_f \phi_{cc}^f + n_c(1+n_f\phi_c^f)\right]f'(Q_t) - C''(x_{tc}^*) - 2\beta_c\delta_c\right]^2}$$

.

Both expressions are negative. This proves the theorem.

Q.E.D.

<u>Proof of Theorem 4</u>: From (7a) and (7b), we have

$$Var(x_{tf}) = E_t(x_{tf} - \bar{x}_f)^2 = \frac{1}{4\beta^2\delta^2} E_t\left[f(Q_t) + \varepsilon_t + f'(Q_t)x_{tf} - C'(x_{tf})\right]^2, \text{ and}$$

$$Var(x_{tc}) = E_t(x_{tc} - \bar{x}_c)^2 = \frac{1}{4\beta^2\delta^2} E_t\left[f(Q_t) + \varepsilon_t + K_t(1 + n_f\phi_c^f)f'(Q_t) - C'(x_{tc})\right]^2.$$

Now, $4\beta^2\delta^2 Var(x_{tf}) = E_t\left\{(f + \varepsilon_t - C')^2 + (f' x_{tf})^2 + 2(f + \varepsilon_t - C')x_{tf} f'\right\}$ and

$$4\beta^2\delta^2 Var(x_{tc}) = E_t\left\{(f + \varepsilon_t - C')^2 + (K_t(1 + n_f\phi_c^f)f')^2 + 2(f + \varepsilon_t - C')K_t(1 + n_f\phi_c^f)f'\right\}$$

.

Thus, with a bit of algebra, we find that $Var(x_{tc}) > Var(x_{tf})$ if

$E_t\left\{\left[x_{tf} - K_t(1 + n_f\phi_c^f)\right]\left[x_{tf} f' + K_t(1 + n_f\phi_c^f)f' + 2(f + \varepsilon_t - C')\right]\right\} > 0$, that is, if

$E_t\left\{\left[x_{tf} - K_t(1 + n_f\phi_c^f)\right]\left[(x_{tc} - \bar{x}_c) + (x_{tf} - \bar{x}_f)\right]\right\} > 0$.

Yet, $(x_{tc} - \bar{x}_c) + (x_{tf} - \bar{x}_f)$ increases as ε increases. Thus, this covariance is positive if

$x_{tf} - K_t(1 + n_f\phi_c^f)$ is an increasing function of ε. Yet,

(A5) $$\frac{\partial}{\partial\varepsilon}\left[x_{tf} - K_t(1 + n_f\phi_c^f)\right] = \frac{\partial x_{tf}}{\partial\varepsilon} - n_c\frac{\partial x_{tc}}{\partial\varepsilon}(1 + n_f\phi_c^f) + K_t n_f \frac{\partial\phi_c^f}{\partial\varepsilon}.$$

From Theorem 3, $\frac{\partial x_{tf}}{\partial\varepsilon} > 0$ and $\frac{\partial x_{tc}}{\partial\varepsilon} > 0$, and from (5), it is easy to check that

$1 + n_f\phi_c^f < 0$, so, the first two terms are positive. Yet, from (5),

$\frac{\partial\phi_c^f}{\partial\varepsilon} = -\frac{2f'/f''}{(x_{tf}^* + 2f'/f'')^2} > 0$. Thus, (A5) is positive. This proves part (i).

Now, consider the difference $\sigma_c^2 - \sigma_f^2$. From (7a) and (7b),

$$Var(x_{tc}) - Var(x_{tf}) = \frac{1}{4\beta^2\delta^2}\left\{(f + \varepsilon_t + K_t(1 + n_f\phi_c^f)f' - C')^2 - (f + \varepsilon_t + x_{tf} f' - C')^2\right\},$$

which decreases with respect to β and δ. This proves (ii).

Denote $\Delta\pi = \pi(x_c^*) - \pi(x_f^*)$ and $\Delta x = x_c^* - x_f^*$. Then we can rewrite (A2) as $\Delta\pi = \Delta x\left(f\left(Q^T\right) + \varepsilon - C'\left(x^n\right)\right)$. Taking derivatives with respect to n_c,

$$\frac{\partial \Delta\pi}{\partial n_c} = \frac{\partial \Delta x}{\partial n_c}\left(f\left(Q^T\right) + \varepsilon - C'\left(x^n\right)\right) + \Delta x f' \frac{\partial Q^T}{\partial n_c}.$$

Yet $Q^T = K_t + (N - n_c)x_f$, and thus $\frac{\partial Q}{\partial n_c} = \Delta x$. Therefore,

$$\frac{\partial \Delta\pi}{\partial n_c} = \frac{\partial \Delta x}{\partial n_c}\left(f\left(Q^T\right) + \varepsilon - C'\left(x^n\right)\right) + f'\left(x_c - x_f\right)^2.$$

From the proof of Theorem 1, $f\left(Q^T\right) + \varepsilon - C'\left(x^n\right) > 0$ and $\frac{\partial \Delta x}{\partial n_c} < 0$, therefore, $\frac{\partial \Delta\pi}{\partial n_c} < 0$.

This proves (iii).

Q.E.D.

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