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Lobbying: Buying and Utilizing Access

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Abstract This paper introduces an alternative to the lobbying literature's standard assumption that "money buys policies". Our model – in which influence-seeking requires both money to "buy access" and managerial time to "utilize access" — offers three significant benefits. First, it counters criticism that the "money-buys-policies" assumption is at odds with reality. Second, its much stronger lobbying incentives weaken the free-rider problem and raise incentives for lobby formation. Third, the model yields testable hypotheses on: the determinants of lobbying incentives; the number of lobbying firms in an industry; and the impact on industry lobbying by the size distribution of firms, contribution limits on firms, world price changes, and the ability to adjust labor employment.

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Keywords Lobbying; free-rider problem; size-distribution-of-firms; world-price; labor-market-flexibility

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1. Introduction

Lobbying is an integral part of economic policymaking. In the United States, the First Amendment to the Constitution lays the legal foundation for individuals and groups to "petition the government for a redress of grievances." The recent economic literature on economic policy making has accounted for the influence of lobbying groups to explain governments' choices of 'actual' as opposed to 'socially-optimal' policies. A standard assumption made in this literature is that interest groups make monetary contributions to policy makers in return for adopting desired policies. In other words, money is accorded the role of directly purchasing policies.

Empirical evidence of monetary contributions is strong.[1] The assertion that they buy policies, however, has been seriously disputed. Austen-Smith (1991) and others have argued convincingly that the assumption of money directly affecting policy choices is both simplistic and unrealistic. First, information transmission is a more important channel for influencing policies than financial contributions. On many issues, policy-drafting legislators possess far less information than firms affected by these policies. Consequently, legislators actively seek information and gladly listen to lobbies. Second, paying money in return for policies is clearly illegal; and, at least in the United States, there is evidence of reasonably consistent law enforcement.[2] A more acceptable characterization of lobbying contributions is to view them as 'buying access' to legislators.[3] Representatives of industries or firms regularly meet with legislators, give them information, and even play a role in drafting legislation. This access to legislators, however, is not free.[4] It is gained by making monetary contributions.

Both politicians and political analysts, when asked about financial contributions, are quite careful in emphasizing that they buy access rather than policies. This 'money-buys-access' characterization also explains why many firms and individuals contribute to more than one party

[1] It is routine for lobbying firms and individuals to contribute large sums of money to legislators' election campaigns.

[2] The conviction of James Trafficant, a United States Congressman from Ohio, of bribery, racketeering, and tax evasion is a recent example.

[3] There is further debate as to what 'buying access' really means, as Austen-Smith (1995) points out. Is it a euphemism for receiving favorable policies, is it just a way to signal a group's concerns, or does it provide the opportunity to meet and convey the group's concerns, as this paper postulates.

[4] In recent discussions on campaign finance reform in the United States, former representative Lee Hamilton (1998) writes that "special interests gain access to Members (of Congress) through campaign contributions and determined lobbying, and often put pressure on Members to vote with them on their key votes." (pg.1) "But the ease by which special interests can manipulate the system and push things through is exaggerated by the public," (pg.2).

or candidate in a given election. Firms buy access to potential winners even when they do not share their policy preferences.[5]

The characterization of money directly buying policies, besides being unrealistic, harbors dire implications for industry lobby formation by firms with common interests. Olson's (1965) classic lobbying model, which links policy outcomes directly to financial contributions, yields the finding that "no one in the group will have an incentive independently to provide any of the collective good once the amount that would be purchased by the individual in the group with the largest F_i was available" (p.28), where F_i stands for the *ith* individual's fraction of total benefits. Hence, at most *one* firm has an incentive to contribute in return for a policy that benefits all of an industry's firms. This conclusion, therefore, raises serious questions about the logical consistency of the lobbying literature's standard pairing of the assumptions that all of an industry's firms lobby and that policies are adopted in return for monetary contributions.[6]

A small, but growing literature has addressed the issue of endogenous lobby formation when monetary contributions directly affect policies. Pecorino (1998) employs a repeated game framework with a trigger strategy to show that all of an industry's firms of equal size might have an incentive to lobby. Pecorino's framework was later adopted by Magee (2002) who endogenized both lobby formation and policy choices. Mitra (1999), on the other hand, established lobby formation without a repeated game by assuming that firms engage in preplay communication. His model also assumes that industries are made up of identical firms and that money is the lobbying instrument. The assumption of identical firms was finally relaxed by Bombardini (2004). Based on the menu-auction approach of Grossman and Helpman (1994), she lets each of the industry's heterogeneous firms decide on whether to enter the lobbying game and what individual contribution schedule to present to its government.

Hillman (1991), in a little-known but truly important paper, discards the assumption of lobbying through monetary contributions. Lobbying by his firms requires that managers spend costly time to influence policy makers. Hillman demonstrates that more than one of many heterogeneous firms might lobby. In fact, all of an industry's firms will participate, even if they are of different size, provided all firm managers possess the same entrepreneurial ability. Monetary contributions play no role in Hillman's model.

Hillman's insights emerge from a lobbying-by-firms model that corresponds to the classic private-provision-of-public-goods model of Bergstrom, Blume, and Varian (1986).

[5] Common Cause (1999) reported that "forty-eight companies gave $125,000 or more to both parties during the 1997-1998 election."

[6] To avoid confronting this 'uncomfortable' issue, some authors simply assume that organized groups already exist and that the free-rider problem has 'somehow' been overcome.

Consequently, the implications from Hillman's model are equally strong. First, all CEOs of lobbying firms spend the same amount of time on entrepreneurial activities even if they differ with respect to entrepreneurial abilities. Different abilities show up as differences in lobbying activities only. When all CEOs possess the same entrepreneurial talent, then all of them lobby if one has an incentive to do so, and all spend the same amount of time on lobbying. Second, there emerges a neutrality relationship between total industry lobbying and the degree of concentration of the lobbying industry: for a given number of lobbying firms, total industry lobbying depends only on the group's total profit and not on the distribution of total profit among its members, *irrespective of whether the CEOs have equal or unequal entrepreneurial abilities* (pg. 132). In other words, if profit serves as a proxy for size, the group's lobbying effort depends on the group's aggregate size but is independent of the contributing firms' size distribution.

Hillman's conclusion on the independence of industry lobbying from the industry's firm-size distribution is not supported by empirical evidence. Gawande (1997) finds a positive and (statistically) highly significant (at the 1% level) relationship between an industry's degree of concentration and its lobbying-contribution level. The underlying reason for why, say, a high degree of concentration yields a large contribution level is that "the same barriers to entry that allow a high degree of concentration also allow firms to reap the full benefits from lobbying" and hence as a group they contribute more.[7]

Our alternative lobbying formulation assumes that *it takes both money and time to lobby effectively*. Lobbying a legislator first involves the making of a financial contribution by the firm to gain access to the legislator. The larger the contribution, the greater is the amount of 'access-

[7] Some studies find no effect and some a negative effect between the industry's degree of concentration and its 'policy-effectiveness' (see, Potters and Sloof, 1996, pg. 417). The inference one might draw, here, is that in the former case the degree of concentration does not affect the industry's contribution-level and in the latter case, the greater (smaller) the degree of concentration, the smaller (larger) the industry's contribution-level. This stands in contrast to Gawande's finding. Now, one shortcoming of these studies is that they do not explicitly examine how concentration affects the level of contribution, but how concentration affects the 'policy-effectiveness' variable. Another, more serious shortcoming lies on the methodological front; while the 'policy-effectiveness' variable is treated as a function of the industry's contribution level, the contribution-level, itself, is considered to be independent of the 'policy-effectiveness' variable. So, e.g., where the policy-effectiveness variable is the level of protection, the protection-level is considered to be a function of the industry's contribution-level but not vice-versa. Now, Gawande, drawing on Bergstrom, Blume and Varian (1986), maintains that the contribution-level, itself, is a function of the level of protection enjoyed by the industry; a higher level of protection makes for higher industry profit (all else equal) which, in turn, allows for a greater level of contribution (in pursuit of an even higher level of protection that will yield an even larger profit) – a kind of 'wealth effect'. It can thus be concluded that these studies, by failing to account for the dependence of the industry's contribution-level on the 'policy-effectiveness' variable, render their results tainted by the 'simultaneity-bias' problem allowing us to place little confidence in them.

time' obtained.[8] Thus, as in Olson and in accord with empirical reality, financial contributions form an essential component of the lobbying process. However, different from Olson, our model's financial contributions do not buy policies.

Once a firm gains access, it can utilize this access to inform and influence the legislator. Preparing for and meeting with legislators, however, requires time on the part of the firm's manager(s). Hence, the firm must reallocate resources away from production and towards access-utilization. Here, we make the narrow assumption that lobbying is done by the firm's CEO rather than some lower-level delegate(s).[9] One might also argue that lobbying is often done by hired professionals rather than the firm's CEO. But even in this case, the CEO must spend much time preparing the firm's policy position and conveying it to the hired lobbyists. Consequently, the above-described reallocation is still present. In so much as lobbying uses up 'entrepreneurial time', we draw on Hillman (1991) in building our model.

By merging key features of Olson's and Hillman's formulations, our model's assumptions, as well as the resulting implications, gain in realism. First, the model's assumptions of money being contributed to and time being spent with policy makers are quite consistent with descriptive characterizations of the lobbying process. Second, the model's implications, that the number of lobbying firms is endogenously determined and that an industry's lobbying effort depends on the size distribution of firms, are quite consistent with real-world observations.

Based on this 'money-buys-access' and 'access-requires-time' specification, we first examine individual firms' incentives to lobby. Larger firms have stronger incentives than smaller firms and, in equilibrium, all, some, or none of an industry's firms might end up lobbying. Second, we examine the effect of a law that imposes a contribution limit on firms. We conclude that lobbying firms not affected by the limit and previously non-lobbying firms have an incentive to step up their lobbying. In fact, it is quite likely that the number of lobbying firms rises in response to contribution limits.

When we examine the influence of an industry's firm-size distribution on its lobbying effort, a mean-preserving, more unequal size distribution of firms is shown to result in a lower

[8] Holt and Wallace (2001) of the Center for Public Integrity, for example, report, that there exist different price tags for joining the Republican Attorneys General Association which pushed for "nonparticipation by Republican attorneys general in lawsuits against corporations' interests." $25,000 provided "preferred seating" at events, offering private conversations; $15,000 secured tickets to events and access to conference calls; while $5,000-10,000 offered less access.

[9] USA Today, in a report on the lobbying of Net firms writes that "Most of the lobbying is done by the companies' CEOs, who fly to Washington periodically to visit lawmakers." Schwab (1994), in her detailed examination of the making of the *Omnibus Trade and Competitiveness Act*, notes concerning the *plant*

lobbying effort by the entire industry. And when we evaluate an entire industry's lobbying reaction to an exogenous price change, we find that a decline in the world price raises the industry's total lobbying. This is in keeping with the real-world observation of the U.S. steel industry revving-up its lobbying effort following a decline in world steel prices in the late 1990s (see Griswold (1999)). It is worth noting here that the increase in the industry's lobbying effort is carried by the largest firms who definitely expand their lobbying. Smaller firms, on the other hand, might lower and possibly even discontinue their lobbying in response to a price decline.

Finally, we explore the relationship between an industry's lobbying and its firms' ease of adjusting inputs. We find an industry's lobbying response to be weaker the more easily it adjusts its non-managerial inputs such as labor. Our model thus uncovers a (testable) link between labor laws that impinge on firms' labor-adjustment ability[10] and the industry's lobbying effort. Labor-market reform measures that enhance this adjustment-ability not only improve labor-market efficiency but also deliver the 'benefit' of tightening the reins on lobbying.

2. The Model

Consider an industry with N firms in a small, open economy. All firms produce the same homogeneous good X and have the same production function. They may, however, differ in size. The production function has the form:

(1) $$x_j = g(H_j)F(L_j, K_j)$$

where x_j denotes the output of firm j ($j = 1, ..., N$) and H_j, L_j and K_j are the corresponding inputs of management, labor, and capital, respectively. All managers have the same ability, and management time enhances the productivity of labor and capital at a decreasing rate; that is, the $g(.)$ function is the same for all firms, $g'(.) > 0$, and $g''(.) < 0$.[11] The sub-production function $F(L_j, K_j)$ is homogeneous of degree one in labor and capital, and it has positive, decreasing marginal products. It can be restated as:

(2) $$F(L_j, K_j) = K_j f(\lambda_j)$$

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closing provision that "it was primarily a small hard core group of individual firms and the administration that did the most lobbying against the provision " (p.170).

[10] One such law would be a ban on the hiring of certain types of individuals; for instance, children below a certain age.

[11] When we examine the relationship between total lobbying of an industry and the size-distribution of its firms, we add the assumption that $g'''(.) \geq 0$, as would be the case when $g = H^{\gamma}$ and $0 < \gamma < 1$.

where λ_j indicates the jth firm's use of labor per unit of capital, $f'(\lambda_j) > 0$ and $f''(\lambda_j) < 0$. At the time of the lobbying decision, each firm's capital stock, K_j, is already in place and cannot be adjusted. A firm's capital stock serves as a measure of its size.

We now order the industry's N firms from the largest to the smallest by assigning subscripts such that:

(3) $$K_1 \geq K_2 \geq ... \geq K_N .$$

Concerning the employment of labor, initially we assume that it is already in place and cannot be adjusted when the lobbying decision is made. Later, when we analyze the industry's lobbying response to an exogenous price change, this assumption is relaxed.

It is a firm's CEO who provides the management input.[12] Each CEO possesses one unit of time that is to be allocated between the tasks of managing the firm and lobbying the legislator. This is represented by:

(4) $$H_j = 1 - A_j$$

where A_j denotes time spent on lobbying by the CEO of firm j and H_j is time spent on management. Concerning the effect of management-time, we set $g(0) = g > 0$ and $g(1) = 1$.

A legislator charges price B per unit of access-time. If firm j wants to obtain A_j units of access-time, then it must make a monetary contribution C_j, such that:

(5) $$C_j = BA_j .$$

The purpose of gaining access is to lobby the legislator for raising the domestic price of good X, denoted by P, above the exogenously given world price, π. The domestic price function is:

(6) $$P(A, \pi) = \pi + p(A)$$

where $A = \sum_{j=1}^{N} A_j$ measures the industry's total access or lobbying time when the N largest firms lobby, and where $A_j \geq 0$, $p'(A) > 0$ and $p''(A) < 0$. The more total time all the industry's

[12] With regard to the compensation for the 'services' that the CEO provides, we implicitly assume that she receives the entire profit earned by the firm, if she is its owner and if she is an employee, then she receives a fixed percentage of the profit.

CEOs spend on informing, discussing, and pressuring legislators, the larger the gap between domestic and world price.[13]

Lobbying requires both time and money. If the CEO did not have to trade off management for lobbying time, the $g(.)$ term in equation (1) would be unaffected by lobbying, making $g(H_j) = g(1) = 1$, whereas equation (5) would hold as written. This would cast our model into the Olson mold. If, on the other hand, no monetary contribution was required to gain lobbying-access, but there is a trade-off between lobbying and managing, we would have $g(H_j) = g(1 - A_j)$ in (1) and $B = 0$ in (5). This would cast our model into the Hillman mold. The respective roles of time and money in shaping a firm's lobbying incentives will become more apparent in the following section.

3. The Firm's Lobbying Decision

This section examines a firm's incentive to lobby under the assumption that its employment of labor cannot be adjusted at the time of the lobbying decision. We implicitly assume that all employment decisions were made in the past, before any lobbying was contemplated. At that time, firms faced the same wage rate, w, and world price, π, and CEOs spent their entire time on the task of management. Consequently, each firm, no matter its size (K_j), chose the same labor-capital ratio (λ).

The jth firm's profit function is given by:

(7) $$R_j(A_j, A_{-j}) = [\pi + p(A_j + A_{-j})]g(1 - A_j)K_j f(\lambda) - K_j[r + w\lambda] - BA_j$$

where A_{-j} denotes total lobbying time spent by firms other than j, r is the rental on capital, and BA_j measures the firm's monetary cost of A_j units of lobbying time. Firm j has an incentive to lobby – such that optimal lobbying, A_j^*, is positive – if $\partial R_j(.)/\partial A_j > 0$ at $A_j = 0$; that is, if:

(8) $$p'(A_{-j}) - [\pi + p(A_{-j})]g'(1) > \frac{B}{K_j f(\lambda)}.$$ [14]

[13] The relationship between monetary contributions and price as summarized by (5) and (6), represents a reduced form of a more elaborate model on the information exchange between CEOs and legislators. A legislator, to maximize political support, requires both money to run campaigns and information to assess the impact of proposed policies. The CEO, in turn, knows that the firm (and she) can benefit from delivering information as she can bias its content. Now, we do not explicitly model this information exchange. What our model, however, does make explicit is that time is needed to transmit information and that more time offers more opportunities to convey information that benefits the firm (and the CEO).

Given all other firms' lobbying efforts, A_{-j}, firm j compares the marginal gain from a higher price, $p'(A_{-j})$ with the sum of the marginal cost of reduced management, $[\pi + p(A_{-j})]g'(1)$, and the price of access-time per unit of output, $B/[K_j\ f(\lambda)]$. Since $p'(A) > 0$ and $p''(A) < 0$, criterion (8) implies:

<u>Proposition 1</u>: *Ceteris paribus, a firm's incentives to lobby are larger,*

(a) the larger its size (K_j);

(b) the less other firms lobby (A_{-j});

(c) the lower the cost of gaining access to the policymaker (B).

If criterion (8), evaluated at $A_{-j} = 0$, fails to hold for any firm, then the industry fails to lobby. If, on the other hand, criterion (8) holds at $A_{-j} = 0$ for at least one firm, then the question becomes how many firms lobby in a non-cooperative lobbying equilibrium. So, let us assume that criterion (8) holds at $A_{-j} = 0$ for $1 \le M \le N$ firms. Then, based on Proposition 1, the largest firm, with capital stock K_1, has the strongest incentive to lobby. Furthermore, if firm 1 were the only lobbying firm, its profit-maximizing choice, $A_1^* > 0$, would be the solution to:

(9) $$p'(A_1^*)g(1-A_1^*) - [\pi + p(A_1^*)]g'(1-A_1^*) = \frac{B}{K_1 f(\lambda)}.$$

Given the largest firm's lobbying choice, any other firm with capital stock $K_j \le K_1$ has an incentive to lobby as well if criterion (8) also holds for $j \neq 1$; that is, if:

(8') $$p'(A_1^*) - [\pi + p(A_1^*)]g'(1) > \frac{B}{K_j f(\lambda)},$$

since $A_{-j} = A_1^*$. To evaluate (8'), compare it with (9), after noting that $g(1-A_1^*) < g(1) = 1$ and $g'(1-A_1^*) > g'(1)$. Clearly, the LHS of (8') always exceeds the LHS of (9). The RHS of (8'), on the other hand, is larger than (equal to) the RHS of (9) if $K_j < K_1$ ($K_j = K_1$) It follows:

[14] Note that $g(1) = 1$ and that the profit-function is strictly concave in A_j.

<u>Proposition 2</u>: *(a) If each of* $j = 1, ..., M$ *<u>unequal-sized</u> firms has an incentive to lobby when no other firms lobby (* $A_{-j} = 0$ *), then at least one and possibly all* $M > 1$*firms lobby in equilibrium.*

(b) If each of $j = 1, ..., M$ *<u>equal-sized</u> firms has an incentive to lobby when no other firms lobby (* $A_{-j} = 0$ *), then all* M *firms lobby in equilibrium.*

The first part of Proposition 2 states that, if there are M unequal-sized firms and each of them would lobby if all other firms did not, then the equilibrium number of lobbying firms can be as small as one and as large as M . Now, examining the lobbying criterion of (8') for sequentially smaller and smaller firms, the size of the marginal lobbyist, K_H , is determined by the conditions that this firm has an incentive to lobby if the firm of size K_{H-1} (and each firm larger than firm $H-1$) lobbies and the next smaller firm of size K_{H+1} (and each firm smaller than $H+1$) does not lobby; that is:

(10) $$p'(A^{H-1}) - [\pi + p(A^{H-1})]g'(1) > \frac{B}{K_H f(\lambda)} \quad \text{and}$$

(11) $$p'(A^{H}) - [\pi + p(A^{H})]g'(1) < \frac{B}{K_{H+1} f(\lambda)}$$

where $A^H = \sum_{j=1}^{H} A_j$ is total lobbying time spent by the H largest firms (where $1 \le H \le M$).

The second part of Proposition 2 states that, in equilibrium, each of the M equal-sized firms lobbies, if the representative firm has an incentive to lobby when no other firm lobbies. This follows from a comparison of (9) with (8') when $K_1 = K_2 = ... = K_M$

We have demonstrated that the number of endogenously determined lobbying firms can be one, some, all or none. In what follows, we examine the forces behind this finding by relating our model to the specifications of Olson and Hillman. Olson's (1965) model rests on the assumption that lobbying consists of making monetary contributions for directly purchasing policies. Since lobbying has no impact on a CEO's management input, this implies in the context of our model that $g(H_j)$ is independent of A_j, making $g(H_j) = g(1) = 1$. This, in turn, implies that equations (9) and (8') – constituting the conditions for more than one firm to lobby – reduce

to $p'(A_1^*) = B/[K_1\ f(\lambda)]$ and $p'(A_1^*) > B/[K_j\ f(\lambda)]$, respectively. Clearly the inequality of the second condition cannot hold if the equality of the first one does. Whereas the LHS is the same for both equations, $K_j \leq K_1$ implies that the RHS of the second condition cannot be less than the RHS of the first condition. Consequently, no other firm has an incentive to lobby if the largest firm lobbies – just as Olson concludes. We note in this context that Olson's characterization of the use of money to obtain the desired policy measures turns lobbying into a constant-cost activity – that is, the marginal cost of lobbying becomes constant.

Hillman's (1991) model rests on the assumption that lobbying requires no financial contribution on the part of a firm; instead, it calls for involvement by its CEO who faces a trade-off between managing and lobbying. This leads Hillman to the conclusion that, when all CEOs have the same ability, either none or all of an industry's firms lobby. Now, the management trade-off assumption is reflected in our characterization of the lobbying process, but the absence of money is not. Eliminating monetary contributions simply implies that our $B = 0$. Substituting $B = 0$ in (8), the jth firm has an incentive to lobby when no other firms lobbies if $[p'(0) - [\pi + p(0)]g'(1)] > 0$. But if this condition is satisfied for one firm, then it must be satisfied for all N of the industry's firms, *independent of their size*. Hence, they all lobby in equilibrium. Lobbying by $1 \leq H < N$ firms cannot occur. Were only the H largest firms to lobby, then $[p'(A^H)g(1-A_h^*) - [\pi + p(A^H)]g'(1-A_h^*)] = 0$ would be satisfied for the hth firm choosing $A_h^* > 0$, where A^H is again total lobbying by the H largest firms and $h = 1, ..., H$. But then it also must be that $[p'(A^H) - [\pi + p(A^H)]g'(1)] > 0$ for each non-lobbying firm since $1 = g(1) > g(1-A_h^*)$ and $g'(1) < g'(1-A_h^*)$. Hence, in equilibrium, all N firms have an incentive to lobby and, in equilibrium, $[p'(A^N)g(1-A_j^*) - [\pi + p(A^N)]g'(1-A_j^*)] = 0$ for all $j = 1, ..., N$. Since this yields the same A_j^* for all j, it follows that $A_j^* = A^N/N$. Thus without financial contributions, the trade-off between lobbying and managing introduces a strong bias in favor of collective lobbying by all the industry's firms.[15] This bias is the consequence of lobbying being an increasing-cost activity when, as assumed, managing raises output at a decreasing rate.

[15] Hillman allows entrepreneurial ability to vary among firms. How heterogeneity in management abilities affects the number of lobbying firms depends on the way heterogeneity is introduced. If, for example, $g_j = \alpha_j H_j^\gamma$ and $\alpha_1 > \alpha_2 > ... > \alpha_N$ where $H_j = 1 - A_j$, then all firms lobby if one does. If, on the other hand, $g_j = H_j^\gamma$ and $H_j = T_j - A_j$, where $T_1 > T_2 > ..T_N$, then it is quite possible that firms with less entrepreneurial ability do not lobby.

4. Lobbying Equilibrium

An industry lobbying equilibrium is established when none of the M already lobbying firms has an incentive to adjust their lobbying and none of the $(N-M)$ non-lobbying firms has an incentive to start lobbying. Hence, in a non-cooperative lobbying equilibrium:

$$p'(A^M)g(1-A_m^*)-[\pi+p(A^M)]g'(1-A_m^*)=\frac{B}{K_m f(\lambda)} \qquad \text{for } m=1,...,M \tag{12}$$

$$p'(A^M)-[\pi+p(A^M)]g'(1)\le\frac{B}{K_n f(\lambda)} \quad , \qquad \text{for } n=M+1,...,N \tag{13}$$

where $A^M=\sum_{m=1}^{M}A_m^*$ represents total industry lobbying and M is endogenously determined. The M equations of (12) are best-lobbying-response functions of the lobbying firms. A sufficient condition for the equilibrium to be unique is that the best-response functions' slopes are less than one in absolute value for all firms (Eichberger, 1993, p.105). Differentiating (12) with respect to A_j, where $j=1,...,M$ and $j\neq m$, the slope of any such response function is:

$$\frac{dA_m^*}{dA_j}=\frac{-\sigma_m}{(\sigma_m+\rho_m)} \tag{14}$$

where $\sigma_m=\left[p''(A^M)g(1-A_m^*)-p'(A^M)g'(1-A_m^*)\right]<0$

and $\rho_m=\left[\pi+p(A^M)]g''(1-A_m^*)-p'(A^M)g'(1-A_m^*)\right]<0$.

Clearly, the absolute value of the slope of the response function is less than one for all m and j.

We next consider the influence of a firm's size on its lobbying. Looking at (12), note that the equilibrium value of A^M is the same for all firms, as are the values of B and $f(\lambda)$. What differs among firms is the value of K_m, such that $\left(\partial A_m^*/\partial K_m\right)=-B/\left[\rho_m K_m^2 f(\lambda)\right]>0$ implies:

<u>Proposition 3</u>: *Larger firms always lobby more than smaller firms.*

Although larger firms lobby more than smaller firms, this does not mean that they also lobby more relative to their size. If one defines $a_m^*=A_m^*/K_m$ as the mth firm's optimal lobbying per

unit of capital, then $\left(\partial a_m^* / \partial K_m\right) > 0$ if $B > -\rho_m K_m A_m^* f(\lambda)$. This condition is likely to be satisfied for the smallest lobbying firms since K_m is very small. The RHS's value, however, rises with K_m and the condition might no longer be satisfied for the largest firms. Lobbying per unit of capital is not necessarily greater for the largest firm than for slightly smaller firms.

5. Contribution Limits and Lobbying Incentives

Suppose an upper limit of $\overline{C} > 0$ is imposed on how much money a firm can contribute to legislators' election campaigns (or more generally, for lobbying purposes). This, in turn, implies an upper limit (of, say, $\overline{A} > 0$) on how much access-time an individual firm can acquire. Concerning such a lobbying constraint, we establish:

Proposition 4: *The imposition of a lobbying constraint that is binding on some but not all lobbying firms:*

a. *Definitely raises lobbying by firms on whom the constraint is not binding;.*
b. *Possibly increases the number of lobbying firms, as it heightens the incentives of non-lobbying firms to join the lobby.*

With $M < N$ lobbying firms and no lobbying constraints, equations (12) and (13) must hold, where $A^M = \sum_{m=1}^{M} A_m^*$. If now a lobbying constraint, $\overline{A}$, is imposed such that $\overline{A} < A_h^*$ for firms $h = 1, ..., H < M$, then the H largest firms are directly affected. If this were the only departure from the unconstrained equilibrium, such that the remaining *(M-H)* firms would still exert lobbying efforts A_m^*, then (12) would change to:

$$(12') \qquad p'(A^{M'})g(1-\overline{A}) - [\pi + p(A^{M'})]g'(1-\overline{A}) > \frac{B}{K_h f(\lambda)} \qquad \text{for } h = 1, ..., H$$

$$(12'') \qquad p'(A^{M'})g(1-A_m^*) - [\pi + p(A^{M'})]g'(1-A_m^*) > \frac{B}{K_m f(\lambda)} \qquad \text{for } m = H+1, ..., M$$

where $A^{M'} = H\overline{A} + \sum_{m=H+1}^{M} A_m^* < A^M = \sum_{m=1}^{M} A_m^*$.[16] Consequently, all already lobbying firms have incentives to lobby more. While the contribution limit prevents the H largest firms from making adjustments, the smaller $(M-H)$ lobbying firms are able to expand their engagement. Also, since $\left[p'(A^M) - [\pi + p(A^M)]g'(1)\right] < \left[p'(A^{M'}) - [\pi + p(A^{M'})]g'(1)\right]$, so far non-lobbying firms have stronger incentives to lobby. It, therefore, is quite possible that for the largest of the $(N-M)$ pre-constraint non-lobbying firms, we have:

$$\left[p'(A^M) - [\pi + p(A^M)]g'(1)\right] \leq B/\left[K_n f(\lambda)\right] \text{ without constraint, but}$$

$$\left[p'(A^{M'}) - [\pi + p(A^{M'})]g'(1)\right] > B/\left[K_n f(\lambda)\right] \text{ with constraint.}$$

6. Size Distribution of Firms and Industry Lobbying

Concerning the relationship between the size-distribution of firms and the industry's lobbying effort, we state:

<u>Proposition 5</u>: *Provided* $g'''(H) \geq 0$, *a more unequal size-distribution of lobbying firms implies less total lobbying by the industry. The number of lobbying firms, however, might grow as the size-distribution becomes more unequal..*

Given an initial cumulative firm-size distribution, $G(K, s_1)$, a new distribution, $G(K, s_2)$, is considered to be more unequal if, at a constant mean, $\int_0^{K_j} \left[G(K, s_2) - G(K, s_1)\right] dK \geq 0$ for all $0 \leq K_j \leq \overline{K}$, where $\overline{K}$ denotes the largest firm's size.[17] If any two of the M currently lobbying firms changed their sizes such that $dK_i + dK_j = 0$, then the mean of the distribution would remain the same. If, furthermore, $K_i > K_j$ and $dK_i > 0$, then the distribution becomes more unequal, as defined above. Stated more intuitively, if a larger firm expands at the expense of a smaller firm, the industry's size distribution becomes more unequal. Accordingly, we evaluate the impact of a more unequal size distribution on total industry lobbying by evaluating:

[16] Since $A^{M'} < A^M$, the equality of (12) turns into the inequality of (12') for firms with binding constraints; and it turns into the inequality of (12") for firms with no binding constraint when lobbying of the firm under consideration is evaluated at the original lobbying equilibrium.

[17] For further explanations, see Laffont (1993).

(15) $$\left[\frac{\partial A^M}{\partial K_i} - \frac{\partial A^M}{\partial K_j}\right] dK_i \quad \text{for } K_i > K_j \text{ and } dK_i > 0$$

where $A^M = \sum_{m=1}^{M} A_m^*$ and we assume, for the time being, that the number of lobbying firms, M, remains unchanged. Based on differentiating the M equations of (12) with respect to K_j, as shown in Appendix A, equation (16) expresses the lobbying response by the *jth* firm itself, equation (17) shows the lobbying response of each of the other firms, and equation (18) states the entire industry's lobbying response to a change in the size of firm *j*:

(16) $$\frac{\partial A_j^*}{\partial K_j} = -\left(\frac{B}{K_j^2 f(\lambda)}\right)\left[\frac{\left(1+\sum_{m\neq j}^{M}(\sigma_m/\rho_m)\right)}{\rho_j\left(1+\sum_{m=1}^{M}(\sigma_m/\rho_m)\right)}\right] > 0$$

(17) $$\frac{\partial A_i^*}{\partial K_j} = \left(\frac{B}{K_j^2 f(\lambda)}\right)\left[\frac{\sigma_i}{\rho_i\rho_j\left(1+\sum_{m=1}^{M}(\sigma_m/\rho_m)\right)}\right] < 0$$

(18) $$\frac{\partial A^M}{\partial K_j} = \sum_{m=1}^{M}\left(\frac{\partial A_m^*}{\partial K_j}\right) = -\left[\frac{B}{\left(K_j^2 f(\lambda)\rho_j\right)\left(1+\sum_{m=1}^{M}(\sigma_m/\rho_m)\right)}\right] > 0\,.$$

Substitution of (18) into (15) for i and j then yields:

(19) $$\left[\left(\frac{\partial A^M}{\partial K_i}\right) - \left(\frac{\partial A^M}{\partial K_j}\right)\right] dK_i = \left[\frac{-1}{\rho_i K_i^2} + \frac{1}{\rho_j K_j^2}\right]\left[\frac{B}{f(\lambda)\left(1+\sum_{m=1}^{M}(\sigma_m/\rho_m)\right)}\right] dK_i < 0$$

for $dK_i > 0$. The value of $-\rho_m = -\left[[\pi + p(A^M)]g''(1-A_m^*) - p'(A^M)g'(1-A_m^*)\right] > 0$ rises with K_m, provided $g'''(H) \geq 0$, since A^M is given and A_m^* is positively related to K_m. It follows that $-\rho_i K_i^2 > -\rho_j K_j^2$ for $K_i > K_j$ in the first bracket of the RHS of (19). And since the

expression of the second bracket on the RHS in (19) is always positive, a more unequal size distribution of firms reduces the industry's overall lobbying effort.

The intuition underlying the above finding, focusing on the role of access cost – since this is the key feature that distinguishes our setting from that of Hillman, runs as follows. For the contracting firm j, the percentage increase in the price of access per unit of capital is much greater than the percentage decrease in the price of access per unit of capital experienced by the expanding firm i. This leads firm j to cut its lobbying time by more than the corresponding lobbying expansion by firm i, resulting in a fall in the total lobbying time of the industry. In Hillman's setting, since access is costless (although time spent lobbying is not), firm j does not undertake as sharp of a cut in its lobbying time. In fact, in Hillman, the cut in lobbying time by firm j matches the expansion in lobbying time by firm i, leaving total industry lobbying unchanged.

Finally, if the more unequal size-distribution of firms is associated with less industry lobbying for a given number of M firms, there now emerge added incentives for so-far non-lobbying firms to become active lobbyists under the more unequal distribution. Hence, an industry with a more unequal-size distribution of firms might have more lobbying firms but lobby less in total than an industry with a more equal-size distribution of firms.

6. Firm and Industry Lobbying Responses to an Exogenous Price Change

Firms can adjust their profits either through lobbying for a higher price or through producing more. When managerial resources are required for both lobbying and producing, there exists a trade-off between the alternative ways of influencing profits. A CEO's optimal allocation of management time between lobbying and managing is, therefore, critically affected by any exogenous change, such as a change in the world price of the good produced by the firm.

Concerning the impact of a change in the world price, π, on individual firms' and the entire industry's lobbying, we obtain:

Proposition 6: *If the world price of the industry's good declines,*

a. *The largest lobbying firm always lobbies more.*
b. *The smallest lobbying firm's response is indeterminate. In fact, it might lobby less, and possibly even turn into a non-lobbying firm.*
c. *The industry as a whole always lobbies more..*

Assume initially that the number of lobbying firms before and after the fall in price remains the same (say, at M). As shown in Appendix B, the impact of a declining world price on the jth firm's profit-maximizing lobbying response is:

$$\text{(20)} \qquad \frac{\partial A_j^*}{\partial \pi} = \left[\frac{g'_j}{\rho_j} + \sum_{m \neq j}^{M} \left(\left(g'_j \sigma_m - g'_m \sigma_j \right) / \left(\rho_j \rho_m \right) \right) \right] \Bigg/ \left[1 + \sum_{m=1}^{m} \left(\sigma_m / \rho_m \right) \right].$$

The denominator of the above expression is always positive, since $(\sigma_m / \rho_m) > 0$. Concerning the numerator, the first component, (g'_j / ρ_j), is always negative. The sign of the second component, on the other hand, is not determinate as it depends on the signs of $(g'_j \sigma_m - g'_m \sigma_j)$ for all $m = 1,..,M$ other than j. With the substitution of the full expressions for σ_m and σ_j, we get: $(g'_j \sigma_m - g'_m \sigma_j) = p''(A^M)[g'_j g_m - g'_m g_j]$, where $g'_j = g'(1 - A_j^*) > g'_m = g'(1 - A_m^*)$ and $g_j = g(1 - A_j^*) < g_m = g(1 - A_m^*)$ for $K_j > K_m$, using Proposition 3. Accordingly, for the largest firm of size $K_1, (g'_1 \sigma_m - g'_m \sigma_1) < 0$ for all $m \neq 1$ and the price-fall always results in more lobbying. On the other hand, for the smallest lobbying firm of size K_M, $(g'_M \sigma_m - g'_m \sigma_M) > 0$ for all $m \neq M$. So, accounting for both the first and second component in the numerator, the smallest lobbying firm's response to the price-fall is indeterminate; one cannot preclude the possibility that this firm's lobbying declines when the world price falls. For the next smallest firm $M-1$, $(g'_{M-1} \sigma_m - g'_m \sigma_{M-1}) > 0$ for all $m \neq M, M-1$, while $(g'_{M-1} \sigma_m - g'_m \sigma_{M-1}) < 0$ for $m = M$. It thus is quite possible that this second-smallest lobbying firm lobbies less as well; but this response is less likely than it is for the smallest lobbying firm M. More generally, one can see that, as the influence of these negative terms rises with the size of the firm, larger and larger firms are increasingly likely to lobby more as the world price falls.

To highlight the different influences on a firm's lobbying response, we substitute the domestic price function of (6) in the firm's first-order condition of (12) and differentiate it with respect to π, yielding:

$$\text{(21)} \qquad \frac{dA_m^*}{d\pi} = \frac{g'(1 - A_m^*)}{\rho_m} - \frac{\sigma_m}{\rho_m} \frac{dA^M}{d\pi}.$$

The first term on the RHS is always negative, meaning that, at constant industry lobbying, A^M, all already lobbying firms increase their lobbying in response to a world price decline. The second term on the RHS, on the other hand, is positive since, as will be shown in (22), total or industry lobbying must rise in response to the price decline. Accordingly, an individual firm's lobbying effort can decline only if the rise in industry lobbying is sufficiently large to more than offset the decreased lobbying of the firm (at constant industry lobbying).

The industry's total lobbying response to a price decline can be ascertained by summing of (20) for all M lobbying firms and noting that $\sum_{j=1}^{M}\sum_{m\neq j}^{M}\left(g'_j\sigma_m - g'_m\sigma_j\right)=0$. This yields:

$$\frac{\partial A^M}{\partial \pi} = \sum_{j=1}^{M}\frac{\partial A_j^*}{\partial \pi} = \frac{\sum_{j=1}^{M}\left(\frac{g'_j}{\rho_j}\right)}{\left[1+\sum_{m=1}^{m}\left(\sigma_m/\rho_m\right)\right]} < 0. \tag{22}$$

Hence, industry lobbying always rises as the world price declines.

We started the evaluation of lobbying responses under the assumption that the number of actively lobbying firms remains M. As should be apparent from the above discussion, the number of lobbying firms is endogenously determined. It could decrease, increase, or remain constant. As mentioned, it is quite conceivable that for the smallest of all lobbying firms, the first component of the RHS numerator of (20) is overpowered by the second component and the firm stops lobbying in response to the world price decline. But, as (21) indicates, this can happen only if industry lobbying rises substantially. If, on the other hand, the first component on the RHS numerator of (21) is larger than the second component, then such a firm definitely raises rather than discontinues its own lobbying.

8. Lobbying Responses to Price Changes when Labor Employment is Variable.

The preceding section established a negative relationship between the world price, π, and total industry lobbying. We obtained this result under the assumption that, at the time of the lobbying decision, each firm's capital stock, as well as its labor employment is given. We now relax this assumption and permit each firm to adjust the use of labor when it lobbies. Our objective is to examine how the industry's lobbying is affected by its firms' ability to adjust employment. To highlight the influence of flexible labor employment, we make the simplifying assumption of an industry with equal-sized firms and establish:

Proposition 7: a. *The ability to adjust labor employment is a partial substitute for lobbying. The industry's lobbying response to an exogenous price change is weakened by its firms' ability to adjust labor.*

b. *The offsetting effect of adjustable labor use could be so strong that industry lobbying falls rather than rises in response to a decline in world price.*

The assumption that all N firms are of the same size means that the representative firm of size $K_j = K$ has an incentive to lobby when no other firm does if $\left[p'(0) - [\pi + p(0)]g'(1)\right]f(\lambda) > B/K$. We assume this to be the case and denote industry lobbying by A, such that each firm's lobbying is $A_j = A/N$.

The firm's profit-maximizing choice of labor is obtained by maximizing (7) with respect to $\lambda = L/K$, yielding the first-order condition:

$$[\pi + p(A^*)]g(1-(A^*/N))f'(\lambda^*) = w. \tag{23}$$

Since $f''(\lambda) < 0$, the optimal labor-capital employment ratio is positively related to both the world price, π, and the industry's total lobbying, A. Each firm's lobbying choice, in turn, results in a non-cooperative equilibrium if:

$$\left[p'(A^*)g(1-(A^*/N)) - [\pi + p(A^*)]g'(1-(A^*/N))\right]f(\lambda^*) = \frac{B}{K} \tag{24}$$

Given the above equilibrium conditions, we now change the world price π.[18] Differentiating (23) and (24) with respect to π yields:

$$\frac{dA^*}{d\pi} = \frac{g' + \Psi}{\Omega - \dfrac{\Psi\left[p'g - \left(Pg'/N\right)\right]}{g}}, \tag{25}$$

where $P = [\pi + p(A^*)]$, $p' = p'(A^*)$,

$\Omega = \left[p''g - p'g' + (Pg''/N) - (p'g'/N)\right] = \left[\sigma + (\rho/N)\right] < 0$,

and $\Psi = (p'g - Pg')\left[(f')^2/(Pff'')\right] < 0$ at the optimal choice.

[18] The wage rate w is held constant. It is implicitly assumed that the industry in question is sufficiently small relative to the entire economy so that a reallocation of labor between industries leaves the wage rate unaffected.

With regard to the sign of $\left(dA^{*}/d\pi\right)$, the denominator of (25) is negative if, as we assume here, adjustments in the economy's labor market are 'dynamically stable'.[19] The sign of the numerator, on the other hand, is indeterminate since $g' > 0$ and $\Psi < 0$. Consequently, more lobbying in response to a world price decline is no longer assured when firms can adjust their labor employment; industry lobbying might rise or it might decline.

In order to trace the influence of adjustable labor employment on an industry's total lobbying effort, we return to (24) and differentiate it with respect to π. After simplification, we obtain:

$$\frac{dA^{*}}{d\pi} = \frac{g'}{\Omega} - \frac{d\lambda}{d\pi}\left[\frac{Pf''\Psi}{\Omega f'}\right], \tag{26}$$

Note, here, that substituting the expression for $\frac{d\lambda}{d\pi}$ (which is obtained by differentiating (23) with respect to π) yields (25). Hence, (26) is just another way of stating (25). Now, $\frac{d\lambda}{d\pi}$ is zero (positive) if firms are unable (able) to alter their employment-level. One can thus see (26) as decomposing the impact of a world-price change on the industry's lobbying effort into a 'price effect'(as represented by $\frac{g'}{\Omega}$) and an 'employment effect' (as represented by $-\frac{d\lambda}{d\pi}\left[\frac{Pf''\Psi}{\Omega f'}\right]$). Focusing on the contribution of the 'employment effect', a world-price reduction, for instance, by lowering the employment-level (at the given level of lobbying) must have a curtailing effect on the industry's lobbying effort (since $-\frac{d\lambda}{d\pi}\left[\frac{Pf''\Psi}{\Omega f'}\right]$ is positive).

Finally, it is easily shown that the industry lobbying response to a world price change is always weaker with employment adjustment than without it. The former was expressed by (25); the latter is given by $\frac{dA^{*}}{d\pi} = \frac{g'}{\Omega}$. Given the assumption that labor market adjustments are dynamically stable, a comparison of these expressions shows that:

$$-\left.\frac{dA^{*}}{d\pi}\right|_{d\lambda=0} > -\left.\frac{dA^{*}}{d\pi}\right|_{d\lambda\neq 0}. \tag{27}$$

[19] Adjustments in the economy's labor market are dynamically stable if raising the value of the marginal product of labor in the industry under consideration relative to the rest of the economy attracts labor from the rest of the economy, even after accounting for adjustments in lobbying.

Hence, the influence of adjustable labor employment is such that it always counteracts the lobbying effort. In fact, it possibly counteracts so strongly that it leads to a reversal in the direction of the lobbying response. In all situations, the firm's ability to adjust its employment acts as a substitute for its ability to lobby.

9. Concluding Remarks

This paper formulated a lobbying-by-firms model that highlights the influence of monetary contributions to buy access to politicians and of management time to make use of this access. This merging of Olson's assumption that money buys policies and Hillman's assumption that lobbying competes with management time yields a more realistic modeling of the actual lobbying process than can be found in the current literature. Equally important, the model's implications offer useful hypotheses about major forces that influence an industry's lobbying effort: the size of individual firms, the size distribution of firms, the existence of a legal restriction on a firm's lobbying contribution, the world price of the industry's output, and the firms' ability to adjust inputs in response to world price changes.

The most disturbing implication of Olson's 'money-buys-policies' assumption is that the inherent free-rider problem is so severe that it becomes very difficult to explain why many or all of an industry's firms engage in lobbying. This difficulty is most pronounced when firms are of different size. The characterization of lobbying as a repeated game by Pecorino (1998), as a one-shot game with pre-play communication by Mitra (1999), and as a common-agency game by Bombardini (2004) offer potential resolutions to this logical inconsistency inherent in the usual pairing of the money-buys-policies and all-firms-lobby assumptions. Pecorino's repeated game and Mitra's pre-play communications models restore logical consistency of these assumptions under the restriction that all firms of an industry are of the same size. Bombardini's common agency model is, to our knowledge, the only successful attempt to establish logical consistency between the money-buys-policies and many-firms-lobby assumptions when firms are allowed to be of different size. The model of our paper represents what we believe to be a more realistic, alternative approach to explaining how some or all of an industry's firms use money to influence the lobbying process. By adding Hillman's feature of a trade-off between lobbying and managing to the traditional feature that money matters we can show that some, all, or none of an industry's firms have an incentive to lobby. And by assuming that money buys access to politicians, the use of money conforms to the campaign contribution laws of the United States and many other countries far better than by assuming that money buys policies.

Our model yields two kinds of insights. The first kind concerns the impact of different external forces on the lobbying effort of individual firms. It is shown that an increase in a firm's size raises its incentives to lobby. A legal restriction on how much a firm can contribute, of course, reduces lobbying by firms on whom the constraint is binding; but it raises the lobbying efforts of already lobbying firms that are not restricted by the constraint and they create lobbying incentives for firms that, so far, did not lobby. That a contribution-limit may, in fact, expand the 'policy-making' influence of some firms ought to goad campaign-finance reformers into undertaking a more rigorous examination of this 'limits-issue'. Finally, a rise in the world price of the industry's good definitely leads to a smaller lobbying effort by the largest firms; but it might raise lobbying by the smallest firms.

Secondly, we gain insights with respect to the impact of different external forces on the lobbying effort of the entire industry. This effect is, of course, relevant for explaining the endogenous formation of economic policies. We demonstrate that an industry's total lobbying is sensitive to the size distribution of firms. Under certain restrictions on the firm's production function, a more unequal size distribution of firms is shown to lead to a decline in industry lobbying. A legal restriction on the political contribution of individual firms results in a decline in industry lobbying even though individual firms might lobby more than before; the cutback in lobbying by firms directly affected by the constraint is never completely made up by the increased lobbying of firms not directly affected by the constraint. Lastly, when firms lack the ability to adjust factor-inputs, such as labor, a fall (rise) in the world price leads to an expansion (contraction) in the industry's lobbying effort. The ability to adjust factor-inputs, now, mutes the industry's lobbying response. This can be a 'blessing' or a 'curse'. In the case of industries confronting declining (rising) world prices, a greater ease of adjustment may even shrink (enlarge) their respective lobbying efforts and prove to be a 'blessing' ('curse'). Whether, in fact, the ease of adjustment bears this two-faced nature is left to future work to uncover.

Appendix A: Derivations of the Expressions for $\partial A_j^* / \partial K_j$ and $\partial A_i^* / \partial K_j$

[Note: $j = 1, ..., M$; $i = 1, ..., M$ **]**

The M equations of (12) describe a non-cooperative equilibrium for the M actually lobbying firms. Differentiating these functions with respect to K_j yields:

$$\text{(A.1)} \qquad \begin{pmatrix} (\sigma_1 + \rho_1) & \sigma_1 & \sigma_1 & . & . & \sigma_1 \\ \sigma_2 & (\sigma_2 + \rho_2) & \sigma_2 & . & . & \sigma_2 \\ \sigma_3 & \sigma_3 & (\sigma_3 + \rho_3) & . & . & \sigma_3 \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ \sigma_M & \sigma_M & \sigma_M & . & . & (\sigma_M + \rho_M) \end{pmatrix} \begin{pmatrix} \partial A_1^* / \partial K_j \\ \partial A_2^* / \partial K_j \\ \partial A_3^* / \partial K_j \\ . \\ . \\ \partial A_M^* / \partial K_j \end{pmatrix} = \begin{pmatrix} S_m \\ S_m \\ S_m \\ . \\ . \\ S_m \end{pmatrix}$$

where:
$$\sigma_m = \left[p''(A^M) g(1 - A_m^*) - p'(A^M) g'(1 - A_m^*) \right] < 0,$$
$$\rho_m = \left[[\pi + p(A^M)] g''(1 - A_m^*) - p'(A^M) g'(1 - A_m^*) \right] < 0$$

for $m = 1, ..., M$; $S_m = 0$ for $m \neq j$ and $S_m = -B / \left[K_j^2 f(\lambda) \right] < 0$ for $m = j$

Now, whether we can determine the expressions for $\partial A_j^* / \partial K_j$ and $\partial A_i^* / \partial K_j$ by simply applying Cramer's rule would depend, of course, on whether the first matrix on the LHS of (A.1) is non-singular. Let us check if this is so. The determinant, Δ, of this matrix is given by:

$$\text{(A.2)} \qquad \Delta = \prod_{m=1}^{M} \rho_m \left[1 + \sum_{m=1}^{M} \left(\sigma_m / \rho_m \right) \right]$$

Since $\sigma_m < 0$ and $\rho_m < 0$, $\Delta > 0$ if M is even and $\Delta < 0$ if M is odd. With $\Delta \neq 0$, the matrix is non-singular and we can indeed apply Cramer's rule.

Applying this rule, then, it is easily determined that:

$$\text{(A.3)} \qquad \frac{\partial A_j^*}{\partial K_j} = -\left(\frac{B}{K_j^2 f(\lambda)} \right) \left[\frac{\left(1 + \sum_{m \neq j}^{M} \left(\sigma_m / \rho_m \right) \right)}{\rho_j \left(1 + \sum_{m=1}^{M} \left(\sigma_m / \rho_m \right) \right)} \right] > 0$$

(A.4) $$\frac{\partial A_i^*}{\partial K_j} = \left(\frac{B}{K_j^2 f(\lambda)}\right)\left[\frac{\sigma_i}{\rho_i \rho_j \left(1 + \sum_{m=1}^{M} (\sigma_m / \rho_m)\right)}\right] < 0 \ .$$

Appendix B: Derivation of the expression for $\partial A_j^* / \partial \pi$

Differentiating the M equations of (12) with respect to π, we obtain:

(B.1) $$\begin{pmatrix} (\sigma_1 + \rho_1) & \sigma_1 & \sigma_1 & . & . & \sigma_1 \\ \sigma_2 & (\sigma_2 + \rho_2) & \sigma_2 & . & . & \sigma_2 \\ \sigma_3 & \sigma_3 & (\sigma_3 + \rho_3) & . & . & \sigma_3 \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ \sigma_M & \sigma_M & \sigma_M & . & . & (\sigma_M + \rho_M) \end{pmatrix} \begin{pmatrix} \partial A_1^* / \partial \pi \\ \partial A_2^* / \partial \pi \\ \partial A_3^* / \partial \pi \\ . \\ . \\ \partial A_M^* / \partial \pi \end{pmatrix} = \begin{pmatrix} g_1' \\ g_2' \\ g_3' \\ . \\ . \\ g_M' \end{pmatrix}$$

where $g_i' = g'(1 - A_i^*),\ i = 1, ..., M$ and σ_m, ρ_m (where $m = 1, ..., M$) are as defined earlier. Note that we can obtain the expression for $\partial A_j^* / \partial \pi$ by once again applying Cramer's rule. Applying this rule, then, it is determined that:

(B.2) $$\frac{\partial A_j^*}{\partial \pi} = \left[\frac{g_j'}{\rho_j} + \sum_{m \neq j}^{M} \left(\left(g_j' \sigma_m - g_m' \sigma_j\right) / (\rho_j \rho_m)\right)\right] \Big/ \left[1 + \sum_{m=1}^{M} (\sigma_m / \rho_m)\right].$$

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