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Endogenous Technological Change via Industry Lobbying: Closed versus Open Economy Models*

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Since the markets typically fail in the optimal provision of public goods, and in the absence of an all knowing government, collective action by the polity can, in principle, induce government to allocate public goods to their highest social rewards. In reality, this process is prone to failure too. The paper focuses on this nexus. This is achieved by the construction and simulation of a two-sector overlapping generations model where producers lobby government for the factor-augmenting public input. Consistent with theories of rent seeking behavior, the direction of technological change is viewed as the consequence of lobbying for *cost-reducing sector-specific public input.*

Closed economy results show that producers demand technology that augments the expensive factor. This result is not consistent with the direction of technological change suggested by the induced innovation hypothesis (IIH) arguing that market signals favor the technology that intensively uses the abundant factor. *Small, open economy* results indicate that, in a relatively capital (labor) abundant economy, the political system supplies policies favoring the labor (capital) intensive sector, which again contradicts the IIH. Furthermore, terms of trade favoring the capital (labor) intensive sector induce the benevolent government to heavily supply labor-augmenting (capital-augmenting) public input.

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I. Introduction and Background

Empirical evidence shows differences in total factor productivities (TFP) across industries (Costello, 1993), while the contributors to the new growth theory suggest that the growth experiences of some of the world's fastest growing economies can be attributed, in part, to the success governments have had in resolving problems of market failure (Stiglitz, 1996). Recent studies, including Griliches (1979), Bernstein and Nadiri (1988), and Nadiri and Mamuneas (1994), find that these efficiency gains are associated with public and private investments in R&D, they also find that such investments tend to be factor biased.[1]

Since the products of R&D investments are akin to knowledge, they tend to be non-rival in the sense that their use by one does not preclude their use by another, and only partially excludable in the sense that many new products and processes can be reverse engineered, or a new patent can be obtained from the ideas embodied in the previous patent. Consequently, firms cannot appropriate the full rewards to their investments in R&D capital. In this case, they tend to underinvest in R&D capital, which in turn tends to result in a lower rate of economic growth than would otherwise be socially optimal. Since governments too have problems of incomplete information, collective action by the polity to inform government of where the returns to public R&D are likely to be relatively high can, in principal, induce governments to overcome the market failure problem by providing public R&D capital through competitive research grants to firms, research organizations, and to universities and other quasi-public organizations. Of course, given the frailty of most political processes, it is possible for one interest group to lobby too effectively relative to others which can cause a mis-allocation of public investment on R&D to less socially profitable sectors of the economy. Moreover, lobby groups tend to lobby for the type of R&D capital that biases factor productivity in their favor. Thus, the design of a mechanism that lowers the possibility of the government's failure in the allocation of public R&D capital is critically important to growth and the maintenance of competitiveness in world markets.

1. The terms "public R&D", "R&D capital", and "public input" are interchangeably used throughout this study.

We construct a two-sector overlapping generations model (OGM) where the government, the only provider of public input, attempts to provide R&D capital to each sector based on the lobbying efforts of sectoral representatives. That the signals conveying information about the nature of market failure are provided by producers' lobbying activities opens the policy decision to the influence of political pressure. Consistent with theories of rent seeking behavior, our study views the path of technological change as the consequence of lobbying government for cost-reducing sector-specific public input (North, 1991). Cross-industry differences in TFP can then be, in part, attributed to effectiveness the mechanism to provide public R&D capital to various sectors of the economy.

The present study links technological change and lobbying in a two sector model where the capital-intensive (CI) and labor-intensive (LI) sectors lobby government (Janvry, Sadoulet, Fafchamps, 1989; Alston, Chalfant, and Pardey, 1993). The result of lobbying is either CI or LI public input that induces technical changes. Thus, the path of technological change is determined by the rules and regulation defining the nature of lobbying and the constraints on the government's fiscal policy. To this end, the purpose of this study is (i) to contrast the direction of technological change driven by lobbying with the direction suggested by a benevolent government and (ii) to analyze the steady-state welfare implications of these two directions.

The simulation results for both closed and small, open economy models suggest that producers' lobbying efforts gain momentum when the cost of the intensively employed factor increases. Specifically, the producers in the LI (CI) sector increase lobbying for the labor (capital) augmenting technology, when labor (capital) becomes relatively more expensive. This result confirms the internal consistency of the lobbying model constructed. As a result, the path of technological change in the lobbying economy is no longer consistent with the path suggested by the induced innovation hypothesis (IIH) which predicts that technical changes occur so as to use the most abundant factor of production. The results also show that lobbying can lead to excess supply of public input and that the central planner's first best fiscal policy is to impose heavy taxes on capital.

The organization of the paper is as follows. Following a brief introduction, Section II describes the lobbying economy model. Section III formulates the optimal lobbying in a Nash noncooperative, two-person game. Section IV and V describe endogenous technological change and the welfare consequences of lobbying, respectively. Section VI discusses simulation results for closed and small, open economies. Finally, Section VII draws some conclusions.

II. A Two-Sector Lobbying Economy Model

This is a two-sector, two-goods overlapping generations model (OGM): a perishable consumption good, Y^*, and an investment good, Y (Galor, 1991).[2] The consumption and investment goods are produced by the LI and CI production technologies using capital, labor, and public input, respectively. Cost reducing public input enters production functions in the form of industry-specific knowledge or research findings and increases the productivity of private factors of production (Barro, 1990).

The initial labor endowment, $\overline{L_0} > 0$, and the initial capital endowment, $\overline{K_0} > 0$, are exogenously given. It is assumed that the total labor force in the economy is constant, that is, $\overline{L} = 1$ for all t.

II. 1. Industries

Given (w, r, p^*, Y^*, s^*, Φ, Φ^*, G, $\overline{G}$), a representative firm in the investment goods producing sector maximizes its profit by choosing (Y, K, L, s):

2. We extend Galor's model by introducing public input, the third input, and lobbying for its distribution between the two sectors. For notational convenience, the variables without superscript (i.e., x), except input prices, belong to the investment goods producing sector; the ones with superscript (*) (i.e., x^*) belong to the consumption goods producing sector. The aggregate variables are denoted by a bar over the variable (i.e., $\overline{x}$). Unless otherwise stated, all the variables are assumed to have time t subscript.

$$
(\Pi_{max})\left\{\begin{array}{l}
\text{Max } \Pi = Y - wL - rK \\
\text{s.t. } Y = (1-s)\left[\theta(e^{\lambda G}K)^{\rho} + (1-\theta)(e^{(1-\lambda)G}L)^{\rho}\right]^{(\gamma/\rho)} \\
G = \left[\frac{\Phi s Y}{(\Phi s Y + \Phi^{*} p^{*} s^{*} Y^{*})}\right]\overline{G} \\
Y \geq 0,\ K \geq 0,\ L \geq 0,\ 0 \leq s \leq 1 \\
\text{given } (\overline{L}_0, \overline{K}_0) > (0,0).
\end{array}\right.
$$

Output Y is produced by employing capital K, labor L, and public input, G. The economy-wide supply of public input, $\overline{G}$, is distributed between the two sectors by applying the distribution rule (the second constraint). The variable s denotes the proportion of output spent in lobbying. The terms, $e^{\lambda G}$ and $e^{(1-\lambda)G}$, are capital and labor augmentation functions, respectively. The investment good is numeraire, i.e., $p^{*} \equiv \left(\frac{p^{*}}{p=1}\right)$. Wage, w, and rental rate, r, define the wage-rental ratio denoted by $\omega \equiv \left(\frac{w}{r}\right)$. The elements of $(\Phi, \theta, \lambda, \gamma, \sigma)$ respectively denote the efficiency coefficient of converting lobbying into pressure, the coefficient of capital intensity, the efficiency coefficient of the capital-augmenting (CA) public input, the coefficient of returns to scale, and the elasticity of substitution between capital and labor where $\sigma = 1/(1-\rho)$.

Manipulating the FOCs of (Π_{max}) yields

$$
k = \left[\frac{\omega}{((1-\theta)/\theta)e^{\rho(1-2\lambda)G}}\right]^{\sigma} \equiv k(\omega;G)
$$

where $k \equiv (K/L)$ is the capital-labor ratio. Assumption 1 states that the investment good is capital-intensive for all feasible ω and (G, G^{*}).

Assumption 1. $k(\omega;G) > k^{*}(\omega;G^{*})\ \forall(G, G^{*}) \geq 0$ and $\forall \omega > 0$.

The stability of the model is guaranteed by Assumption 2(i)

(Craven, 1973). Assumption 2(ii) indicates the degree of sector-specificity of public input. It assumes that the public input provided to the CI (LI) sector augments capital (labor) more than labor (capital). Assumption 2(iii) says that the production function indicates decreasing returns with respect to (K, L).

Assumption 2. i. $(\sigma \in (0,1),\ \sigma^{*}>1)$,

ii. $(\lambda \in (\frac{1}{2},1),\ \lambda^{*} \in (0, \frac{1}{2}))$,

iii. $1 > \gamma$.

The production function exhibits increasing returns to scale with respect to (K, L, G) and constant returns to with respect to (K, L, M) where M representing managerial skills is not included in the production function so that positive profit in a decreasing returns world (i.e., $\gamma < 1$) is, in fact, the price of managerial skills in a constant returns world (i.e., $\gamma = 1$). This specification of the production function in the form of decreasing returns allows the industries to have resources for their lobbying activities.

II. 2. Endogenous Policy

In this study, the government policy is endogenized by the following institutional rules: (i) producers, knowing that the government accepts any outcome of lobbying, influence government policy decision via lobbying, (ii) the government considers the influence of the already existing institutional structure on its policy decision, and (iii) relative lobbying governs the distribution of public input between the two sectors. The interaction between producers and the government is modeled in two stages (Becker, 1983). The first stage interaction is expressed by a linear pressure function, $B=B(b;\Phi)=\Phi b$, where $b \equiv sY$ and $B \geq 0$. The second stage interaction is represented by an influence function, I(.),

$$I = I(b,b^{*};\Phi,\Phi^{*}) = \left[\frac{B}{(B+B^{*})}\right] = \left[\frac{\Phi b}{(\Phi b+\Phi^{*}b^{*})}\right], \text{ where } (I+I^{*}) = 1.$$

$I_B > 0$ says that, given (Φ^{*},b^{*}), higher lobbying by the investment goods producing sector increases its effectiveness. $I_{BB^*} < 0$ implies that higher lobbying by the consumption goods producing sector decreases the marginal effectiveness of the other sector. The outcome of lobbying is a set of weights, I. Endogenous policy in this context means nothing more than endogenizing these weights.

We incorporate the rules (i) – (iii) into the two stage political process and write the government's policy decision rule, $\mu(.)$, for the sectoral distribution of public input as follows[3]

$$G = \mu(b,b^*;\Phi,\Phi^*, \overline{G}) = I(b,b^*;\Phi,\Phi^*)\ \overline{G}.$$

We call $\mu(.)$ *governance function*. Assumption 3 sets the total revenue in an industry as the upper bound for its lobbying expenditure.

Assumption 3. **i**. $\forall b^*, \exists\ \hat{b}(b^*) < +\infty$ so that $Y \geq \hat{b}(b^*) \geq 0$ and
ii. $\forall b, \exists\ \hat{b}^*(b) < +\infty$ so that $p^*Y^* \geq \hat{b}^*(b) \geq 0$.

Lobbying process is modeled as follows. Each sector represented by a lobby group confronts the governance function announced at the beginning of time t. Thereafter, given $(\Phi,\Phi^*, \overline{G})$, lobbyists extend resources, (b, b^*), to influence the policy decision, (G, G^*). Finally, the government makes the public input available to the sectors in such a way that it can not incur a fiscal deficit.

II. 3. Consumers

The economy consists of overlapping generations of two-period-lived agents and operates in discrete time t with certainty. During the first period, individuals born at time $t \geq 1$ supply their unit-endowment of labor inelastically; earn labor income, $w\overline{L}$, and total profit income,

3. The function, $\mu(.)$, excludes the case where both of the sectors choose not to lobby simultaneously. Simultaneous no-lobbying can be incorporated in our analysis by defining $\mu(.)$ as $G=\left[\frac{1}{\left(1+\frac{1+B^*}{1+B}\right)}\right]\overline{G}$ or $G = \left[\frac{1}{(1+e^{(B^*-B)})}\right]\overline{G}$.

$\overline{\Pi}$; and pay labor income tax, $\tau^L w\,\overline{L}$. In the second period, they supply their savings, S; earn income $(1 + i_{t+1})S$; and pay income tax $\tau^K_{t+1}(1 + i^*_{t+1})S$ where τ^L and τ^K_{t+1} respectively denote labor income tax rate at time t and capital income tax rate at time t+1. The term, $(1 + i_{t+1})$, is the gross rate of return of holding one unit of investment good from t to t+1. There is also an initial old generation at time t = 1 who spends his/her disposable income, $(1 - \tau^K_1)(1 + i_1)S_0$, on the second period consumption $c_0(1)$. Each generation consists of a single individual, therefore the total number of people at time t is equal to $\overline{N} = (N + N_{t-1}) = 2$ where N (N_{t-1}) is the number of young (old) people at time t.

Given $(w, r_{t+1}, p^*, p^*_{t+1}) > 0$, $(\tau^K_{t+1}, \tau^L) \geq 0$, and $\overline{\Pi} \geq 0$, a young person at time $t \geq 1$ chooses $(c_t(t), c_t(t+1), S)$ to maximize his/her utility

$$(U_{max}(t)) \begin{cases} \text{Max } \ln(c_t(t)) + \alpha \ln(c_t(t+1)) \\ \text{s.t. } p^* c_t(t) + S \leq \overline{w}\,\overline{L} + \overline{\Pi} \\ \quad p^*_{t+1} c_t(t+1) \leq \overline{r}_{t+1} S \\ \quad c_t(t) \geq 0,\ c_t(t+1) \geq 0 \\ \quad \text{given } \overline{L} = 1 \end{cases}$$

where $c_t(t)$ and $c_t(t+1)$ respectively stand for time t and t+1 consumption of the person born at time t. The optimal consumption and savings are $c_t(t) = \frac{(\overline{w} + \overline{\Pi})}{(1+\alpha)p^*}$; $c_t(t+1) = \frac{\alpha\, \overline{r}_{t+1}(\overline{\Pi} + \overline{w})}{(1+\alpha)p^*_{t+1}}$; and $S = \frac{\alpha(\overline{w} + \overline{\Pi})}{(1+\alpha)}$. Define $\overline{w} \equiv (1 - \tau^L)w$, $\overline{r}_{t+1} \equiv (1 - \tau^K_{t+1})r^K_{t+1}$, and $\overline{\Pi} \equiv (\Pi + \Pi^*)$. We assume perfect foresight, that is, $E(p^*_{t+1}) = p^*_{t+1}$ where p^*_{t+1} is the rationally anticipated relative price of the consumption good at time t+1. Gross interest rate, $(1 + i_{t+1})$, and the capital tax rate, τ^{K}_{t+1}, are known by both borrowers and lenders at time t. Equilibrium in the capital market requires $r_{t+1} = (1+i_{t+1}) \forall t$.

At time t=1, the initial old generation born at t=0 solves

$$(U_{max}(0)) \begin{cases} \text{Max} & \alpha \ln(c_0(1)) \\ \text{s.t.} & p_1^* c_0(1) \leq \bar{r}_1 S_0 \\ & c_0(1) \geq 0 \\ & \text{given } S_0 = K_1 > 0 \end{cases}$$

where the optimal consumption is $c_0(1) = \bar{r}_1 K_1 / p_1^*$.

Lobbying and next period capital stock is linked through the following two relationships: The young generation saves the investment goods at time t, NS = Y; the savings at time t become the next period capital stock, K_{t+1} = NS. This linkage is crucial in understanding the role lobbying plays in the process of technological change.

II. 4. Passive Government

The passive government is one that only carries out the outcome of lobbying. It finances the production of public input by collection labor and capital income taxes collected from consumers as industries determine its quantity. Its tax revenue is $T \equiv (\tau^{L} w\bar{L} + \tau^{K} r\bar{K})$. Given ($p^g$, T, w, r, τ^L, τ^K), the government maximizes the value of its production by choosing($\bar{G}$, K^g, L^g):

$$(GP) \begin{cases} \text{Max} & p^g \bar{G} \\ \text{s.t.} & T = wL^g + rK^g \\ & \bar{G} = (K^g)^{\delta} (L^g)^{1-\delta}. \end{cases}$$

The total production of public input and government's demand for capital and labor are $\overline{G} = \left[\frac{\delta}{\gamma}\right]^{\delta}\left[\frac{(1-\delta)}{w}\right]^{(1-\delta)}T$, $K^g = \frac{\delta T}{r}$, and $L^g = \frac{(1-\delta)T}{w}$ where p^g is the shadow price of public input.

Definition 1. A Feasible Allocation

Given ($\overline{K}_0$, $\overline{L}_0$) > 0, an allocation $\{c_t(t), c_{t-1}(t), S, Y, G, K, L, s, Y^*, G^*, K^*, L^*, s^*, \overline{G}, K^g, L^g\}_{t=1}^{\infty}$ is feasible if

$Y = (1-s)\ [\theta(e^{\lambda G}K)^{\rho} + (1-\theta)(e^{(1-\lambda)G}L)^{\rho}]^{\gamma/\rho}$

$Y = (1-s)\ [\theta^*(e^{\lambda^* G^*}K^*)^{\rho^*} + (1-\theta)(e^{(1-\lambda)^{G^*}}L^*)^{\rho^*}]^{\gamma^*/\rho^*}$, and

$\overline{G} = (K^g)^{\delta}(L^g)^{1-\delta}$.

Definition 2. Political-Economic Equilibrium

A political-economic equilibrium[4] is *a feasible allocation* with accompanying price system $\{w,r,p^*,p^g\}_{t=1}^{\infty}$, a lobbying system $\{s,s^*\}_{t=1}^{\infty}$, and a tax scheme $\{\tau^K, \tau^L\}_{t=1}^{\infty}$ such that

i. consumers solve $U_{max}(t)$ and $U_{max}(0)$,
ii. representative firm in each sector solves Π_{max},
iii. the government solve GP
iv. the capital market satisfies K_{t+1} = NS for all t, and
v. private factor markets clear: $K + K^* + K^g = \overline{K}$ and $L + L^* + L^g = \overline{L}$, goods markets clear: NS = Y and $(Nc_t(t)+N_{t-1}c_{t-1}(t)) = Y^*$.

Ⅲ. A Noncooperative Two-Industry Game

Lobbying is modeled as a non-cooperative 2-industry game. Players have their strategy sets $\varphi = \{s_h\}_{h=L,N}$ and $\varphi^* = \{s_h^*\}_{h=L,N}$ where

4. The concepts "political-economic equilibrium" and "lobbying equilibrium" are interchangeably used throughout the study.

L denotes lobbying and N no lobbying strategies. The game has the following timing of actions:

1. The government announces $G = \mu(s_h, s_h^*)$.

2. Given ($\overline{G}$, Y^*, p^*, Φ^*, Y, Φ), players simultaneously choose lobbying expenditures ($s_h \in \varphi$, $s_h^* \in \varphi^*$).

3. Finally, the government announces the outcome of lobbying (G, G^*). The lobby group representing the investment goods producing sector has payoff, $\Pi(G;G^*)$, which is the conditional indirect profit function, conditional on $G^* = \mu^*(s_h, s_h^*)$. Similarly, the payoff of the consumption goods producing sector, $\Pi^*(G^*;G)$, is conditional on $G = \mu(s_h, s_h^*)$.

Definition 3. The Nash Equilibrium

In the 2-player normal-form game $G = \{\varphi, \varphi^*; \Pi, \Pi^*\}$, the strategy vector $(\tilde{s}_h, \tilde{s}_h^*)$ is a **Nash equilibrium** if

(i) $\tilde{s}_h$ is the best response to the strategy, $\tilde{s}_h^*$,

$$\Pi(\tilde{s}_h, \tilde{s}_h^*) \geq \Pi(s_h, \tilde{s}_h^*), \quad \forall s_h \in \varphi \quad \text{and}$$

(ii) $\tilde{s}_h^*$ is the best response to the strategy, $\tilde{s}_h$,

$$\Pi^*(\tilde{s}_h, \tilde{s}_h^*) \geq \Pi^*(\tilde{s}_h, s_h^*), \quad \forall s_h^* \in \varphi^*.$$

Ⅳ. Endogenous Technological Change

In our context, technological change means nothing more than the accumulation of public input that enhances the productivity of private factors of production. Following Ahmad (1966), we utilize the concept of innovation possibility curve (IPC) -- defined as an envelop of all the alternative production techniques corresponding to a given output -- to describe technological change: A shift from IPC_t to IPC_{t+1} due to the provision of public input. The rationale behind such shift is the following. A change in the factor-price ratio from ω_1 to ω_2 implies factor substitution in the short run, a movement from e_1 to e_2 on the isoquant Q_{1t}. In the long run, there will be a movement from e_1 to e_3 on the isoquant Q_{2t}. What is observed as a result of changing factor-price ratio is that technological change increases factor substitution away from the factor that becomes relatively more expensive towards the relatively cheaper factor (Figure 1). This is the type of technological change suggested by the IIH (Hayami and Ruttan, 1971; and Ruttan, 1978).

The two-sector lobbying model developed in this study assumes that producers lobby when there is a change in the factor-price ratio. For illustration purposes, let us assume that capital becomes more expensive, which is represented by a shift from ω_1 to ω_2 in Figure 1. The CI sector responds to this increase in the rental rate of capital by increasing its lobbying for the CA public input. The economy therefore starts to operate on the IPC_{t+1}, i.e., a nonneutral shift from IPC_t to IPC_{t+1}. The gap between IPC_t and IPC_{t+1} depends on how intensive the CI sector is in using capital. Assumption 1, stating that the production technique in the CI (LI) sector has to remain CI(LI), suggests that this reaction will be stronger when the CI sector has to use more and more capital over time.

V. Welfare Analysis

In this section, we compare the steady-state welfare across lobbying and no lobbying economies. That overlapping generations model allows for an infinite number of consumers makes welfare analysis particularly demanding since Pareto-dominance entails an ordering of infinite dimensional vectors (Matsuyama, 1991). Therefore, we analyze the steady-state welfare.

Some argues that rent-seeking is inherently welfare-reducing (Tullock, 1967; Buchanan, 1980). Some emphasizes that rent-seeking may be welfare enhancing in the presence of certain kinds of pre-existing market imperfections (Bhagwati, 1982). Some, on the other hand, interestingly shows that the lobbying outcome may be an improvement over the competitive equilibrium under certain conditions (Coggins, 1989). The present study, combining directly unproductive rent-seeking activities with pre-existing market failure, analyzes welfare effects of lobbying under the two cases: (i) producers both lobby and get public input, (ii) producers do not lobby, but the benevolent government provides public input.

Case (i): To examine the association between lobbying and welfare, it is necessary to decompose changes in welfare into changes due to lobbying and changes due to output prices. Substituting the steady-state output price and lobbying expenditures into the indirect utility function, $\hat{V}(\overline{K}^s)$, and totally differentiating the resulting function yield

$$\frac{d\hat{V}(\overline{k}^s)}{d\overline{k}^s} \equiv \left[\frac{\partial \hat{V}}{\partial w}\frac{\partial w}{\partial s} + \frac{\partial \hat{V}}{\partial r}\frac{\partial r}{\partial s}\right]\frac{\partial s}{\partial \overline{K}}$$

$$+ \left[\frac{\partial \hat{V}}{\partial w}\frac{\partial w}{\partial s^*} + \frac{\partial \hat{V}}{\partial r}\frac{\partial r}{\partial s^*}\right]\frac{\partial s^*}{\partial \overline{K}}$$

$$+ \left[\frac{\partial \hat{V}}{\partial w}\frac{\partial w}{\partial p^*} + \frac{\partial \hat{V}}{\partial r}\frac{\partial r}{\partial p^*} + \frac{\partial \hat{V}}{\partial p^*}\right]\frac{\partial p^*}{\partial \overline{K}}$$

where $\overline{K}^s$ denotes the steady-state capital stock. The first and second terms in the above equation represent the effect of changing capital endowment $\overline{K}$ on the welfare through its effect on lobbying expenditures, which impact factor and output prices. The third term reflects the price effect of changing $\overline{K}$ on the welfare.

Case (ii): Given (p^*. $s = s^* = 0$), the benevolent government chooses the vector of variables, (Y, Y^*, G, G^*, K, K^*, K^g, L, L^*, L^g, $\overline{G}$), to solve the following problem:

$$
(\text{BGP})\begin{cases}
\text{Max}\ \ (Y+p^{*}Y^{*}) \\
\text{s.t.}\ \ Y=[\theta(e^{\lambda G}K)^{\rho}+(1-\theta)(e^{(1-\lambda)G}L)^{\rho}]^{(\gamma/\rho)} \\
\qquad Y^{*}=p^{*}[\theta^{*}(e^{\lambda^{*}G^{*}}K^{*})^{\rho^{*}}+(1-\theta^{*})(e^{(1-\lambda^{*})G^{*}}L^{*})^{\rho^{*}}]^{(\gamma^{*}/\rho^{*})} \\
\qquad \overline{G}=(K^{g})^{\delta}(L^{g})^{1-\delta} \\
\qquad \overline{K}=K+K^{*}+K^{g} \\
\qquad \overline{L}=L+L^{*}+L^{g} \\
\qquad \overline{G}=G+G^{*}.
\end{cases}
$$

Totally differentiating the indirect utility function, $\hat{V}(.)$, and evaluating it at $\overline{K^{s}}$ result in

$$
\frac{d\hat{V}(\overline{K^{s}})}{d\overline{K^{s}}}\equiv\left[\frac{\partial\hat{V}}{\partial w}\frac{\partial w}{\partial p^{*}}+\frac{\partial\hat{V}}{\partial r}\frac{\partial r}{\partial p^{*}}+\frac{\partial\hat{V}}{\partial p^{*}}\right]\frac{\partial p^{*}}{\partial\overline{K}}
$$

where $\hat{V}(.)$ and $\hat{V}(.)$ respectively stand for the steady-state welfare levels in the lobbying and no lobbying economies.

VI. Simulation Results

As it is seen from the lobbying economy model outlined in the previous sections, we use specific functions - the CES production function, the governance function, and consumers' utility function - which are all strictly concave with respect to their arguments. The other constraints in the model are linear. This feature of the model guarantees the existence and uniqueness of the political-economic equilibrium (Uzawa, 1962; Stiglitz, 1967; Fisher, 1992). but the model does not have a closed-form analytical solution. Therefore, to understand the properties of the equilibrium we simulate the model.

VI. 1. Closed Economy Results

Table 1 reports the parameter values used in the simulations of the closed lobbying economy model. The influence of the existing institutional structure on the policy formation is assumed to be equal across sectors, that is, $\Phi = \Phi^*$ (i.e., neutral institutional arrangement). Likewise, the institutional bias favoring the CI (LI) sector is characterized by $\Phi > \Phi^*(\Phi < \Phi^*)$. The parameter values $\theta = \lambda = 0.6(\theta^* = \lambda^* = 0.4)$ imply that the investment (consumption) goods producing sector is CI (LI). We choose $\delta = 0.5$ to exclude the influence of the government's demand for private inputs on the aggregate factor-saving bias. Following Tanzi (in Newbery and Stern, 1987), labor and capital income tax rates take values in the interval $0.25 \leq \tau^i \leq 0.30$ where $i = K,L$. The parameters, $\gamma = \gamma^* = 0.8$, imply that industry production exhibits decreasing returns. The parameter, $\rho = -1$ ($\rho^* = (1/3)$), implies that the elasticity of substitution between capital and labor in the CI (LI) sector is $\sigma = 0.5$ ($\sigma^* = 1.5$). The labor and capital endowments are $\overline{L} = 1$ and $1.8 \geq \overline{K} \geq 0.7$, respectively. The parameter α denoting the discount factor is set to be equal to 0.95.

VI. 1.1. Endowments, Fiscal Policy, and Welfare

In this section, we discuss the simulation results regarding the impacts of changes in capital endowment, $\overline{K}$, on the endogenous variables -- capital-labor ratios (k,k^*,k^g), input and output prices (w,r,p^*), lobbying shares (s,s^*), total public input $\overline{G}$, and after-lobbying outputs levels (Y,Y^*). The values of these variables are then used to compute the lobbying expenditures (b,b^*), the sectoral distribution of public input (G,G^*), and welfare. Knowledge of the impacts of changing capital endowment on producers' lobbying efforts is important in understanding why similar countries with respect to their endowments follow different paths of technological change.

To test the internal consistency of the lobbying model, we first investigate the effect of increasing capital endowment on wage-rental ratio and find that the relative scarcity of labor raises wage-rental ratio and hence, raises relative output price, p^*. Increasing wage-rental ratio induces the LI sector to relatively more lobby for labor-augmenting public R&D. As a result, the LI sector obtains more public input than does the CI sector. The above chain of interactions of capital endowment with input-output prices and the sectoral distribution of public input fully supports our expectations (Figures 2(a)-2(d)). This interaction finally generates labor-augmenting technological change. To this end, we conclude that the lobbying economy model is internally consistent for the parameter specification given in Table 1. The scenario of internal consistency is stated as Assertion 1.

Assertion 1. *Lobbying leads to the supply of technology that augments the relatively scarce factor.*

Assertion 1 supports our hypothesis: wherever a factor becomes relatively scarce, the sector that intensively employs that factor heavily lobbies and obtains public input that mainly augments it. This result contradicts the induced innovation hypothesis suggesting that the economy supplies technologies that intensively utilize the abundant factor.

Welfare analysis across different fiscal policies, associated with Cases 1, 2, and 3 in Table 1, indicates that heavy capital income taxes (i.e., $\tau^K > \tau^K$) improve welfare over the alternative fiscal policies (i.e., $\tau^K = \tau^L$ and $\tau^K < \tau^L$) because capital owned by the old generation would be consumed unless the government taxes it out to produce public input (see the group L in Figure 3). The capital tax reduces the consumption of the old generation and performs as consumption taxes.

Assertion 2. *Technological change that makes the old (young) generation worse off (better off) is welfare improving.*

Assertion 2 argues that technological change that leads to lower rental rate of capital induces the old generation to consume less. This implies that lobbying frontiers -- which also represent the zero-profit conditions $\partial C(\hat{w}, \hat{r}, \hat{s}, \hat{s}^*, \hat{p}^*, \hat{Y}, \hat{Y}^*)/\partial s = 0$ and $\partial C^*(\hat{w}, \hat{r}, \hat{s},$

$\hat{s}^*, \hat{p}^*, \hat{Y}, \hat{Y}^*)/\partial s^* = 0$ evaluated at ($w = \hat{w}$, $r = \hat{r}$, $Y = \hat{Y}$, $Y^* = \hat{Y}^*$, $p^* = \hat{p}^*$) -- would shift downward (Figures 4(a) and 4(b)). A downward shift of the frontiers, which are upward sloping and concave in the (s,s^*) plane, corresponds to a higher utility level since the shift towards the origin represents a lower level of lobbying expenditure (compare A_1 in Figure 4(a) with A_2 in Figure 4(b)). Likewise, technological change reducing wage rate implies lower income to the young generation. The frontiers in Figure 4(c) shift upward representing a lower utility (compare A_1 in Figure 4(a) with A_3 in Figure 4(c)). Therefore, we conclude that policies designed to lower rental rate of capital are welfare improving. In other words, the cost of production in the CI sector declines at the expense of old generation's welfare.

Ⅵ. 1.2. Institutional Arrangements and Technological Change

The relationship between institutional arrangements and technological change is examined by simply changing the parameter values of (Φ,Φ^*). There are three kinds of institutional arrangements: neutral (i.e., $\Phi = \Phi^*$), capital-biased (i.e., $\Phi > \Phi^*$),and labor-biased (i.e., $\Phi < \Phi^*$). For example, the capital-biased arrangement states that the CI sector benefits more from the same amount of lobbying expenditures than does the LI sector. In other words, the efficiency rate of lobbying by the CI sector is higher than that of the LI sector.

To numerically illustrate the impacts of this biased institutional setting on technology supply, we solve the model for Case 1 in Table 1 with $\Phi = 5 > \Phi^* = 1$. The results show that the capital-biased arrangement induces the CI sector to lobby more, and as a result, to obtain more public input than does the LI sector (Figures 5(a), 5(b)). The biased arrangement pushes technological change in the direction where the CI sector benefits the most, which we call *positive technology effect*. It is also observed that the biased structure leads to an upward shift in the relative output price, p^*, due to a decline in the rental rate of capital (Figure 6). In turn, raising relative output price reduces the output of the CI sector, and hence weakens its political influence, which we call *negative price effect.* In our model, for an appropriate parameter specification, there is the possibility of immiserizing institutional arrangements when the price effect dominates the technology effect.

Assertion 3. (Immiserizing Institutional Arrangements)
Institutional arrangements biased for the CI (LI) sector lead to an increase in the supply of the CA (LA) public input, which causes a decline in the output price of this sector, which then discourages that sector to produce more, and finally, the same sector weakens in the political market.

For a long time, development economists have investigated the effects of sector-specific increase in productivity on national economic growth. The so-called "Dutch disease" is an example of adverse effect of sector-specific productivity increase on economic growth (Corden, 1984). An example of such adverse effect is *immiserizing growth* in an open economy: An increase in productivity in an export sector is offset by the worsened terms of trade under certain conditions (Johnson, 1955; Bhagwati, 1958). In the context of our lobbying model, an increase in productivity in the CI sector due to favorable institutional arrangements might lead to adverse price effect which offsets the improved productivity.

VI. 1.3. Lobbying vs Optimal Allocation of Public Input

In this section, we compare the paths of technological change implied by lobbying equilibrium allocation and optimal allocation and discuss welfare implications of different paths.

In the lobbying economy model, the sectoral distribution of public input is determined by exogenous institutional rules embodied in the governance function. Strictly positive lobbying shares $(\tilde{s}, \tilde{s}^*) > (0, 0)$, the total production of public input $\tilde{\tilde{G}}$, and the sectoral allocation of public input $(\tilde{G}, \tilde{G}^*)$ are all endogenously determined (i.e., Cases 1, 2, and 3 in Table 1). In the absence of lobbying $(\hat{s}, \hat{s}^*) = (0, 0)$, the benevolent government produces public input, $\hat{\hat{G}}$, and distributes it between the two sectors, ($\hat{G}$, $\hat{G}^*$), to maximize the gross national product (i.e., Cases 4, 5, and 6 in Table 2).

The following results, independent of fiscal policy, are obtained from the comparison of lobbying and optimal allocations. First, the benevolent government always favors the CI sector, that is $\hat{G} > \hat{G}^*$ contrary to the lobbying equilibrium that favors the LI sector, that is $\tilde{G} < \tilde{G}^*$. This comparison also points out that the government allocates more (less) public input to the CI (LI) sector than that implied by the lobbying equilibrium, that is, $\hat{G} > \tilde{G}$ and $\hat{G}^* > \tilde{G}^*$.

> **Assertion 4.** *The benevolent government favors the capital-augmenting technical changes as opposed to the passive government in the lobbying economy. This result is independent of fiscal policies.*

Second, the passive government produces more public input than does the benevolent government, that is $\tilde{\tilde{G}} > \hat{\hat{G}}$ (Table 3).

> **Assertion 5.** *Lobbying leads to excess supply of technology.*

Third, the optimal allocation is always welfare improving over the lobbying allocation, no matter what fiscal policy is implemented (Figure 3). Furthermore, the fiscal policy, $\tau^K > \tau^L$, generates the highest welfare in both lobbying and no-lobbying economies.

VI. 1.4. A Noncooperative Two-Industry Game

The interdependence between the two industries is characterized by a one shot, noncooperative Nash game. It is found that the strategy of *no lobbying* by both sectors yields higher profits for both sectors than does *lobbying* strategy. This suggests that *no lobbying* is welfare improving over *lobbying* from producers point of view, as well. This situation has the flavor of a “prisoners’ dilemma”: the lobbies are drawn into politics by their maximizing choices but the departure from no lobbying makes both lobbies worse off.

In this game, only one *feasible state* emerges: both of the producers lobby. In this state, each producer pursues his/her best strategy but ends up with an outcome in which the payoffs of both producers are smaller than those of some other strategy combinations. The state of *simultaneously no lobbying* by both sectors is, by construction of the governance function, not feasible. Therefore, the payoffs are determined by the benevolent government's allocation of public input. This allocation is obviously superior, although unrealistic, to lobbying equilibrium allocation in terms of welfare gain since the latter uses resources. Finally, the state of lobbying only by one of the industries is indeterminate. (Table 4 reports the results of this lobbying game.)

Ⅵ. 2. Small, Open Economy Results

The main assumption in a small, open economy model is that agents treat the relative world output price, p_w^*, parametrically, i.e., $p_w^* = p^*$.

Ⅵ. 2.1. Endowment Effects

The experiments with different parameter specifications focus on the implications of lobbying for sectoral output. In particular, the Rybczynski theorem is examined. This theorem states that as long as the production of the two goods is strictly positive and the investment goods producing sector is CI, an increase in the economy wide capital-labor ratio, given goods prices p^*, decreases the production of the consumption goods, Y^*, and increases the production of the investment goods, Y.

In the first experiment, we investigate how the country's endowment influences the sectoral output through its impact on lobbying expenditures. Given the parameters in Table 5, the results indicate that capital (labor) abundance strengthens CI (LI) sector in the following sense. When the country is relatively capital abundant, $\bar{k} > 1$, (labor abundant when $\bar{k} < 1$), the CI (LI) sector lobbies more and gets more public input than the LI (CI) sector. The theorem holds when $0.5 \leq \overline{k} \leq 1.3$; and it does not hold when $1.8 \geq \overline{k} > 1.3$ (Figures 7(a), 7(b), 7(c)).

In the present model, the government chooses the level of public input for an exogenously given tax scheme. We observe this scheme having both level and distribution effects. The level effect is the case in which the aggregate production of public input rises with heavy labor income taxes. The distribution effect is the case in which the sectoral share of public input is at a maximal level for both of the sectors when heavy labor income taxes are imposed.

Assertion 6.

1. $\overline{G}(\tau^L > \tau^K) > \overline{G}(\tau^L = \tau^K) > \overline{G}(\tau^L < \tau^K)$, *level effect*
2. $G^*(\tau^L > \tau^K) > G^*(\tau^L = \tau^K) > G^*(\tau^L < \tau^K)$ &
   $G(\tau^L > \tau^K) > G(\tau^L = \tau^K) > G(\tau^L < \tau^K)$, *distribution effect.*

Finally, we find that the endowment structure of the country determines the direction of technological change. For instance, in an economy where labor (capital) is abundant, we observe that the LA (CA) path of technological change is dominant over the CA (LA) path.

Assertion 7. $G^*(.) > G(.)$ *if labor is abundant* & $G^*(.) < G(.)$ *if capital is abundant, which is independent of tax policy.*

Interestingly, it is found that the tax scheme, $\tau^K > \tau^L$, generates the highest welfare. This result together with Assertion 6 implies that welfare improves when the total provision of public input, $\overline{G}$, is at a minimum level (Figure 8).

VI. 2.2. Price Effects

In this section, we examine how changes in the world relative output price affect factor returns and lobbying. This is achieved by testing the Stolper-Samuelson theorem stated as follows. As long as both goods are strictly positive, if the investment good is CI, given the factor endowments, a marginal increase in the relative world price of the consumption good p^* increases the wage rate and decreases the rental rate.

All of the experiments with the parameter specifications in Table 6 assume that the endowments are given (i.e., $\overline{K} = \overline{L} = 1$) and there is an exogenous improvement in the terms of trade in favor of the LI sector (i.e., $p^* > 1$). The results then suggest that the LI sector lobbies more and gets more LA public input; hence, it produces more than the other sector. Put differently, political forces create an enabling environment for the export of the LI (CI) good and direct technological change toward the labor (capital) augmenting path when the terms of trade, p^*, favors consumption (investment) goods (Figures 9(a), 9(b), 9(c)).

Assertion 8. *Given $K = L = 1$, terms of trade favoring the LI (CI) sector, $p^* > 1$ ($p^* < 1$), induce that sector to lobby more and obtain more public input, $G^* > G$ ($G > G^*$), that augments labor (capital).*

On the other hand, the owners of labor (i.e., young generation) continuously become better off, while the owners of capital (i.e., old generation) start to be better off only after the world prices favor the LI sector. This finding suggests that the Stolper-Samuelson theorem holds only when $p^* < 1$ because, in the case of $p^* > 1$, increasing net economywide demand for capital drives rental rates upward (Figures 10(a), 10(b)).

The relationship between fiscal policy and supply of public input indicates that heavy capital income taxes, $\tau^K > \tau^L$, lower the supply when $p^* < 1$, which slowly recovers when $p^* > 1$. On the other hand, the supply continuously raises when $\tau^K < \tau^L$ and $\tau^K = \tau^L$ (Figures 11(a), 11(b), 11(c)). Furthermore, welfare improves when $\tau^K > \tau^L$ (Figure 12).

VI. 2.3. Lobbying vs Optimal Allocation of Public Input

In order to discuss the welfare and technology implications of the gap between the lobbying and optimal allocations of public input, we compare Cases 7, 8, 9, in Table 7 to Cases 4, 5, 6 in Table 6, respectively.

The results indicate that, in all of the above cases, lobbying and optimal allocations of the public input move in the opposite direction. No matter what tax policy is implemented, at a favorable world price $p^* < 1$ ($p^* > 1$) for CI (LI) sector, the benevolent government provides less public input to CI (LI) sector than that it would get by lobbying (Figures 13(a), 13(b)). The simulation results also show that lobbying leads to the overproduction of the public input (Figure 13(c)).

Assertion 9. *There exists a gap between lobbying-driven and optimal allocation of public input, which suggests that the path of lobbying-driven technological change is not consistent with the path supported by the central planner.*

Assertion 10. *Lobbying leads to the overproduction of public input.*

Furthermore, the absence of lobbying always enhances welfare. Consistent with our previous results, relatively higher taxes on capital income are welfare improving in both lobbying and no lobbying economies (Figure 12).

VII. Conclusions

The allocation of public goods is often cast into a framework where a benevolent government behaves as though it seeks to maximize social welfare. In our model, we relax the assumption of the benevolent government and suppose that the government is open to producers' collective action for the provision of public input. The goal is to provide a quantitative assessment of the effects of special-interest lobbying on the path of technological change in contrast to the path suggested by the benevolent planner.

The closed economy results indicate that whenever the cost of the factor intensively used in the production increases, its users increase lobbying. For instance, when labor becomes relatively expensive, the producers in the LI sector increase lobbying for technology that augments labor. Hence, the path of lobbying-driven technological change is no longer consistent with the path suggested by the IIH. The same result is supported in a *small, open economy* context as well.

In both *closed and small, open* economy models, the optimal allocation is welfare improving over the lobbying allocation no matter what the fiscal policy is. In addition, the *first best* fiscal policy is to impose heavy taxes on capital because this policy generates the highest social welfare. A possible reason for this is that capital income tax performs as a consumption tax. It is also observed that lobbying leads to the overproduction of the total public input. Finally, the results show that institutional rules and regulations matter in determining the nature of technological change.

The strategic interactions of lobby groups in the political market are modeled as a non-cooperative game. In this game, th Prisoner's Dilemma outcome emerges.

Table 1 Closed Economy Parameters for Neutral Institutional Arrangements

Case	ρ	ρ^*	λ	λ^*	θ	θ^*	γ	γ^*	$\overline{K}$	τ^L	τ^K	δ	α	Φ
1	-1	$\frac{1}{3}$	0.6	0.4	0.6	0.4	0.8	0.8	$1.8\geq \overline{K}\geq 0.7$	0.275	0.275	0.5	0.95	$\Phi=\Phi^*$
2	-1	$\frac{1}{3}$	0.6	0.4	0.6	0.4	0.8	0.8	$1.8\geq \overline{K}\geq 0.7$	0.30	0.25	0.5	0.95	$\Phi=\Phi^*$
3	-1	$\frac{1}{3}$	0.6	0.4	0.6	0.4	0.8	0.8	$1.8\geq \overline{K}\geq 0.7$	0.25	0.30	0.5	0.95	$\Phi=\Phi^*$

Table 2 Closed Economy Parameters for Optimal Allocation

Case	ρ	ρ^*	λ	λ^*	θ	θ^*	γ	γ^*	$\overline{K}$	τ^L	τ^K	δ	α	$s=s^*$
4	-1	1/3	0.6	0.4	0.6	0.4	0.8	0.8	$1.8\geq \overline{K}\geq 0.7$	0.275	0.275	0.5	0.95	0
5	-1	1/3	0.6	0.4	0.6	0.4	0.8	0.8	$1.8\geq \overline{K}\geq 0.7$	0.30	0.25	0.5	0.95	0
6	-1	1/3	0.6	0.4	0.6	0.4	0.8	0.8	$1.8\geq \overline{K}\geq 0.7$	0.25	0.30	0.5	0.95	0

Table 3 Production of Public Input in the Closed Economy Model

	$\{\tau^L=0.275,\ \tau^K=0.275\}$		$\{\tau^L=0.25,\ \tau^K=0.30\}$		$\{\tau^L=0.30,\ \tau^K=0.25\}$	
$\overline{K}$	Case 4 $\hat{\hat{G}}$	Case 1 $\tilde{\tilde{G}}$	Case 6 $\hat{\hat{G}}$	Case 3 $\tilde{\tilde{G}}$	Case 5 $\hat{\hat{G}}$	Case 2 $\tilde{\tilde{G}}$
0.7	0.229156	0.232112	0.226511	0.229314	0.231867	0.234969
0.8	0.245610	0.247943	0.242875	0.245093	0.248391	0.250847
0.9	0.260979	0.262802	0.258191	0.259916	0.263822	0.265738
1.0	0.275452	0.276850	0.272614	0.273939	0.278331	0.279805
1.1	0.289153	0.290206	0.286284	0.287281	0.292060	0.293170
1.2	0.302191	0.302964	0.299309	0.300033	0.305111	0.305928
1.3	0.314650	0.315197	0.311758	0.312268	0.317573	0.318155
1.4	0.326596	0.326967	0.323703	0.324045	0.329514	0.329911
1.5	0.338086	0.338321	0.335200	0.335412	0.340990	0.341247
1.6	0.349165	0.349302	0.346293	0.346410	0.352050	0.352205
1.7	0.359874	0.359944	0.357021	0.357073	0.362733	0.362821
1.8	0.370245	0.370277	0.367418	0.367431	0.373073	0.373123
Result	$\tilde{\tilde{G}}>\hat{\hat{G}}$		$\tilde{\tilde{G}}>\hat{\hat{G}}$		$\tilde{\tilde{G}}>\hat{\hat{G}}$	

Table 4 Closed Economy Payoff Matrix of 2-Industry Game

Sector: CI/LI	No Lobbying	Lobbying
No Lobbying	($\hat{\Pi}_{s=0}$, $\hat{\Pi}^*_{s=0}$)	Indeterminate
Lobbying	Indeterminate	($\tilde{\Pi}_{s>0}$, $\tilde{\Pi}^*_{s>0}$)

where $\hat{\Pi}_{s=0} > \tilde{\Pi}_{s>0}$ and $\hat{\Pi}^*_{s=0} > \tilde{\Pi}^*_{s>0}$

Table 5 Open Economy Parameters for Endowment Effects

Case	ρ	ρ^*	λ	λ^*	θ	θ^*	γ	γ^*	$\overline{K}$	τ^L	τ^K	δ	α	$p=p^*$
1	-1	1/3	0.6	0.4	0.6	0.4	0.8	0.8	$1.8 \geq \overline{K} \geq 0.5$	0.275	0.275	0.5	0.95	1
2	-1	1/3	0.6	0.4	0.6	0.4	0.8	0.8	$1.8 \geq \overline{K} \geq 0.5$	0.3	0.25	0.5	0.95	1
3	-1	1/3	0.6	0.4	0.6	0.4	0.8	0.8	$1.8 \geq \overline{K} \geq 0.5$	0.25	0.3	0.5	0.95	1

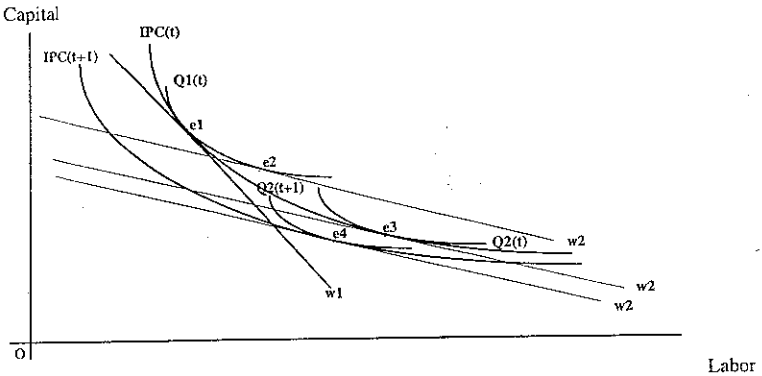
Table 6 Open Economy Parameters for Price Effects

Case	ρ	ρ^*	λ	λ^*	θ	θ^*	γ	γ^*	$\overline{K}$	τ^L	τ^K	δ	α	p^*
4	-1	1/3	0.6	0.4	0.6	0.4	0.8	0.8	1	0.275	0.275	0.5	0.95	$1.15 \geq p^* \geq 0.9$
5	-1	1/3	0.6	0.4	0.6	0.4	0.8	0.8	1	0.3	0.25	0.5	0.95	$1.15 \geq p^* \geq 0.9$
6	-1	1/3	0.6	0.4	0.6	0.4	0.8	0.8	1	0.25	0.3	0.5	0.95	$1.15 \geq p^* \geq 0.9$

Table 7 Open Economy Parameters for Optimal Allocation

Case	ρ	ρ^*	λ	λ^*	θ	θ^*	γ	γ^*	$\overline{K}$	τ^L	τ^K	δ	α	p^*	$s=s^*$
7	-1	1/3	0.6	0.4	0.6	0.4	0.8	0.8	1	0.275	0.275	0.5	0.95	$1.15 \geq p^* \geq 0.9$	0
8	-1	1/3	0.6	0.4	0.6	0.4	0.8	0.8	1	0.3	0.25	0.5	0.95	$1.15 \geq p^* \geq 0.9$	0
9	-1	1/3	0.6	0.4	0.6	0.4	0.8	0.8	1	0.25	0.3	0.5	0.95	$1.15 \geq p^* \geq 0.9$	0

Figure 1 Technological Change in a Lobbying Economy Model



A Hicks-neutral shift in Innovation Possibility Curve (IPC): (e1-e2) = Factor substitution in the short run. (e1-e3) = Substitution of production techniques in the long run. (e3-e4) = A shift from IPC(t) to IPC(t+1) representing "efficiency gain" in production for a given factor price ratio $\omega 2$.

Figure 2 The Impacts of Endowments on Technological Change

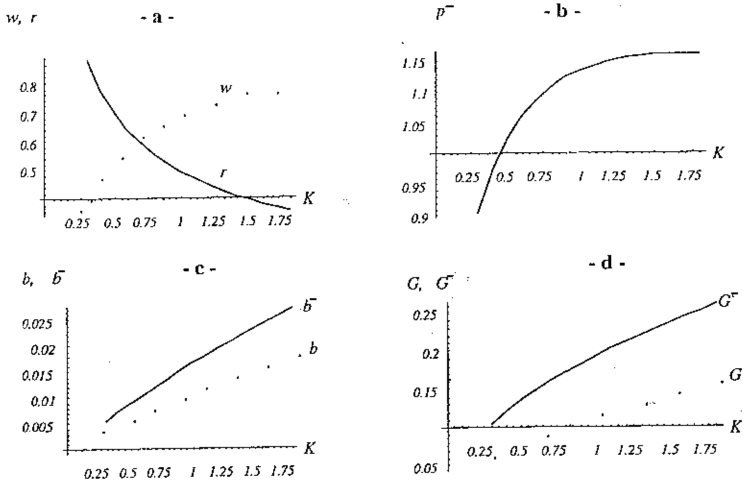


Figure 3 Fiscal Policy, Endowments, and Welfare,
{L = Lobbying, O=Optimal}
{W1 = U1 = ($\tau^K > \tau^L$), W2 = U2 = ($\tau^K = \tau^L$), W3 = U3 = ($\tau^K < \tau^L$)}

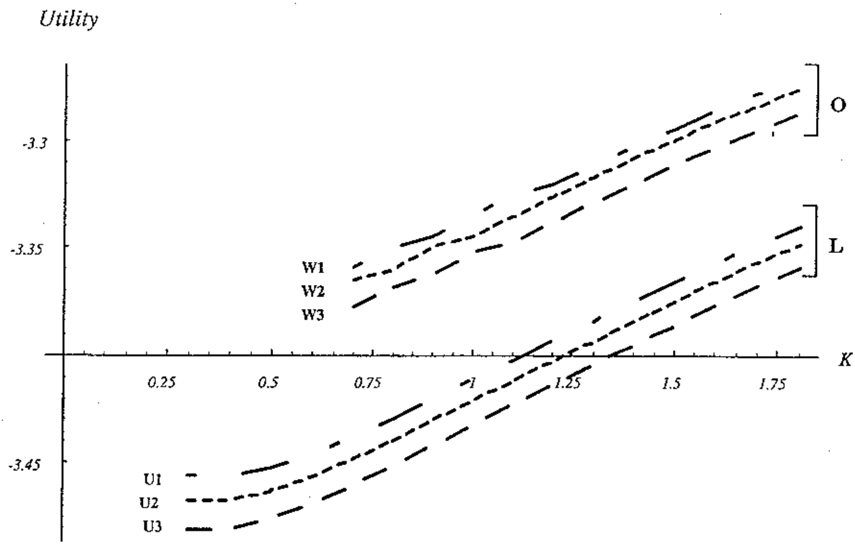
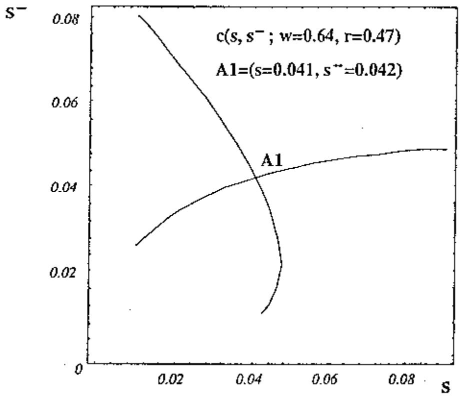


Figure 4 Lobbying Frontiers



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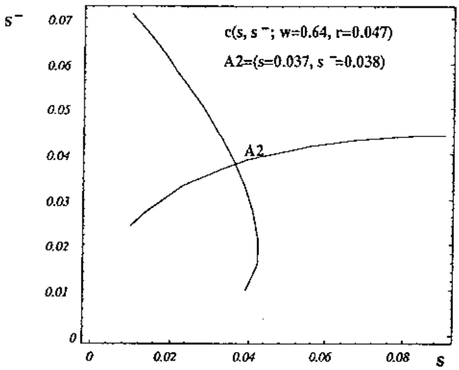

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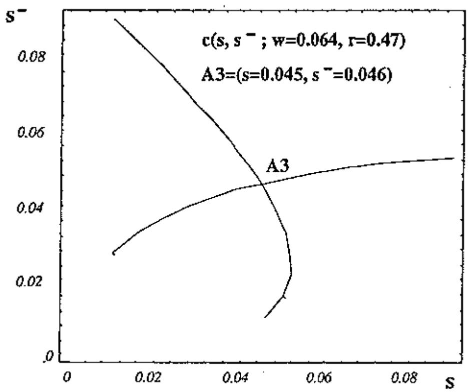

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Figure 5 Technology Effects of Institutional Arrangements, {Φ=5, Φ*=1}

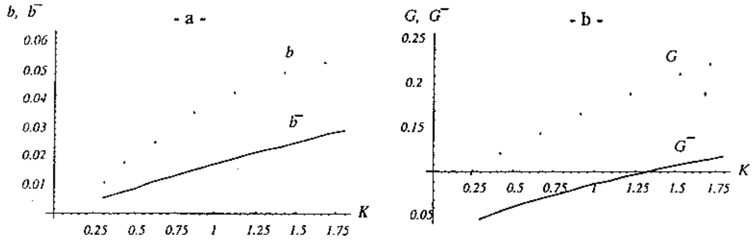


Figure 6 Price Effect of Institutional arrangements, Capital-Biased = {Φ = 5, Φ* = 1} and Neutral = {Φ = Φ* = 1}

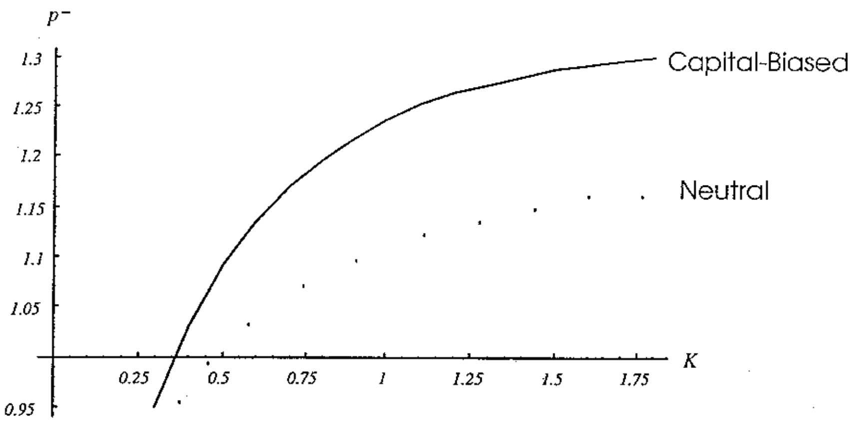
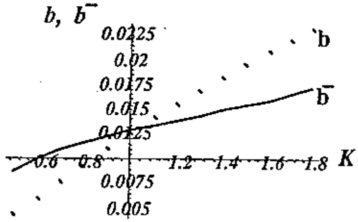


Figure 7 Effects of Endowment on Output and Lobbying, {$\tau^K = \tau^L$}



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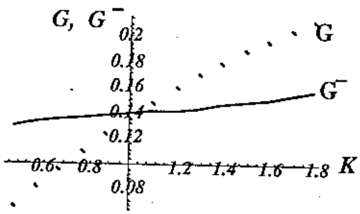

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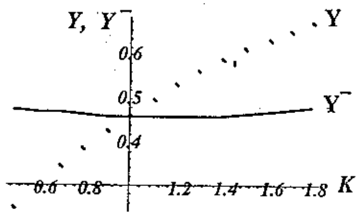

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Figure 8 Welfare Effects of Fiscal Policy, {L = Lobbying}
{U1 = ($\tau^K > \tau^L$), U2 = ($\tau^K = \tau^L$), U3 = ($\tau^K < \tau^L$)}

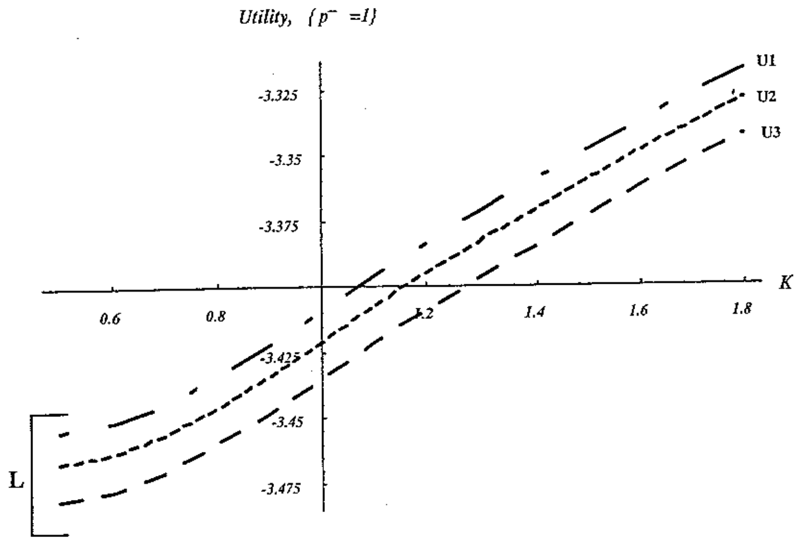


Figure 9 Lobbying and Output Effects of Prices, $\{\tau^K = \tau^L\}$

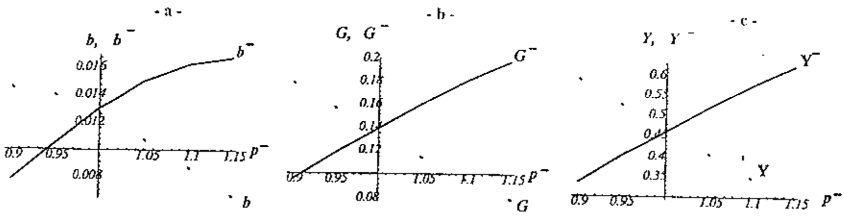


Figure 10 Input Price and Output Effects, $\{\tau^K = \tau^L\}$

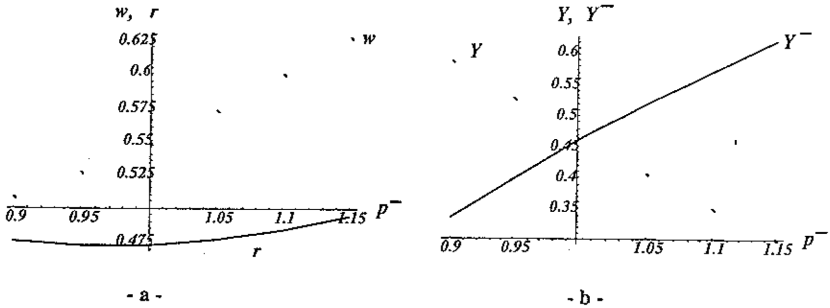


Figure 11(a) Technology Supply across Fiscal Policy, $\{\tau^K = \tau^L\}$

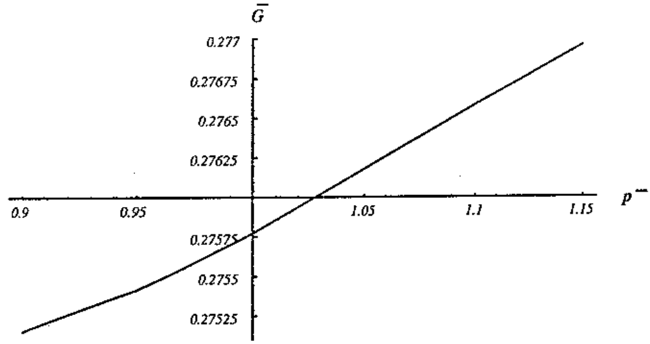


Figure 11(b) Technology Supply across Fiscal Policy, $\{\tau^K < \tau^L\}$

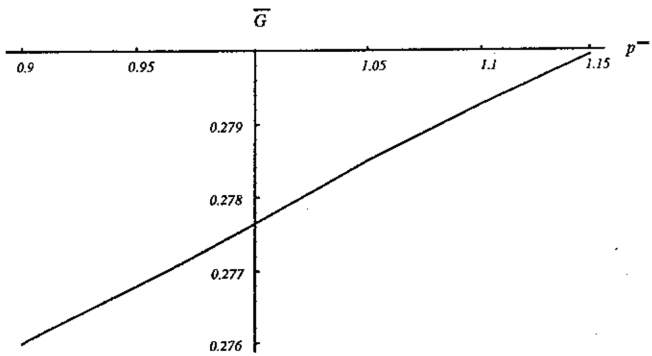


Figure 11(c) Technology Supply across Fiscal Policy, $\{\tau^K > \tau^L\}$

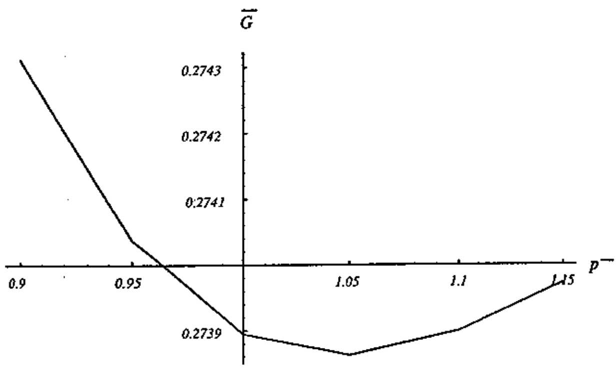


Figure 12 Welfare Across Optimal and Lobbying Allocations, {L = Lobbying, O = Optimal} {W1 = U1 = ($\tau^K > \tau^L$), W2 = U2 = ($\tau^K = \tau^L$), W3 = U3 = ($\tau^K < \tau^L$)}

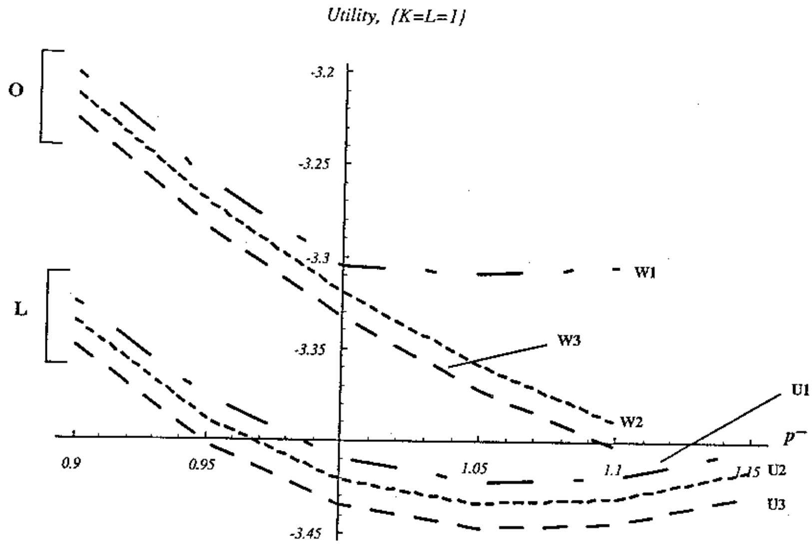
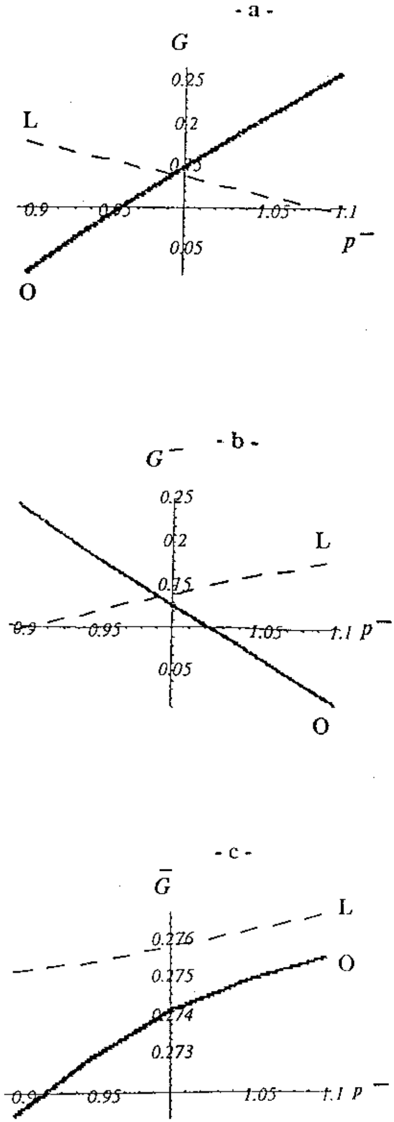


Figure 13 Aggregate Technology Supply and Sectoral Distribution



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