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TECHNOLOGICAL LINKAGES, MARKET STRUCTURE, AND OPTIMUM PRODUCTION POLICIES

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ABSTRACT

There has been an increased interest in the efficacy of industrial policy. We show that policy design for vertically-related industries hinges on the nature of market interactions as well as technological linkages. Using a model in which final-good producers realize productivity gains from increasing domestic specialization of intermediate processes, we find no theoretical basis for presuming that an imperfectly competitive intermediates sector restricts output below the optimal level or that the market produces too many varieties. The direction of distortion depends on the relationship between the extent of the external economy and the market power of individual intermediates producers. Optimal corrective policies require two instruments: an output subsidy and a lump-sum tax or subsidy. If only one instrument is available, it may be optimal to tax instead of subsidize the externality-generating activity.

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1. INTRODUCTION

The potential to benefit by exploiting scale economies and externalities has attracted the attention of policymakers and has generated a heated debate over the efficacy of industrial policy. At the heart of this debate is whether governments must intervene to correct a market that would otherwise produce too little of an externality-generating activity. Activities that generate spillover benefits for interconnected industries dominate the discussion, in principle both because the spillovers may be large and because the inability of the private sector to appropriate the gains seems assured. In such cases public subsidies would seemingly offset private-sector underinvestment caused by limited appropriability.[1]

We show that policy design for interconnected industries is not dictated by technological linkages alone. Rather, optimal policies hinge as well on the nature of market interactions among the affected industries. Using a model in which final-good producers realize productivity gains from increasing domestic specialization of intermediate processes, we compare the market equilibrium to the social optimum. We show that *laissez faire* may be characterized by either too few or too many varieties of intermediate goods and also by either over- or under-exploitation of internal scale economies by the producers of each variety. Thus, we find no basis for presuming that an imperfectly competitive intermediates sector restricts output below the socially optimal level, or that the market produces too many varieties. The model has the appealing feature of highlighting both technological and market forces: the direction of the distortion depends on the relationship between the extent of the external scale economies and the market power of each producer of differentiated intermediates. Optimal corrective policies require two instruments to obtain the best combination of specialized intermediate-good varieties and output per intermediates producer.

To focus on the relationship between market linkages and spillovers, we use a framework that eliminates problems of appropriability caused by international returns to scale and trade in intermediates.[2] When scale economies are international in scope, trade propagates the externality worldwide and calls into question the ability of any single country to affect the source of the returns to scale.[3] With international returns to scale, policy design must weigh the ability of one country to influence and capture the benefits of scale economies, and the concomitant terms-of-trade effects of such manipulation. In contrast, national returns to scale are more easily influenced by country-specific policies. Thus, while we examine a country that is small on final-good markets, the government can control the source of the scale economies and the domestic economy captures fully the benefits of scale economies.

While this framework provides a fertile setting for interventionist policies, we show that the form of intervention may run counter to simple prescriptions for subsidizing industries with external economies. If the government is able to offer both an output subsidy and a lump-sum subsidy, the first-best policy offsets fully the fixed costs of production. This offset, however, is composed of two parts: an output subsidy that ensures marginal cost pricing and either a lump-sum subsidy *or* a lump-sum tax to ensure that the correct number of firms enters the intermediates market. Whether the optimal lump-sum policy is a tax or subsidy is determined by comparing the rate at which additional varieties generate external economies to the rate at which imperfectly competitive input producers appropriate rents. Only if the former exceeds the latter is the optimal policy a lump-sum subsidy.

Even when the government is limited in its choice of instruments, the direction of intervention is indeterminate. For example, if the government can only offer a lump-sum tax *or* subsidy (such as a precommercial development subsidy), we show that a lump-sum tax may be required for the economy to achieve the second-best combination of scale and diversity in the intermediates sector. Hence, the analysis emphasizes that there is no presumption on technological grounds that the externality-generating activity should be subsidized, even in the absence of an instrument to ensure marginal cost pricing.

2. PREVIOUS STUDIES

The modern literature on product diversity and monopolistic competition dates to Spence [1976] and Dixit and Stiglitz [1977]. Dixit and Stiglitz examine the welfare properties of a model distinguished by household preferences that reflect a desire for variety in consumption and by its adoption of the Chamberlinian notion of monopolistic competition. Increasing returns in the production of each variety of consumption good limit the extent of diversity that the market can provide. Dixit and Stiglitz show that when monopoly power enables firms to pay fixed costs and entry cannot be prevented, the relationship between monopoly power and the direction of market distortion is not obvious. They do not characterize the optimal interventions but it is clear that the first-best entails pricing at marginal cost and the financing of fixed costs by a lump-sum tax on consumer's income.[4]

There are numerous applications of the Dixit-Stiglitz model to open economy settings; we focus briefly on those concerned with policy design.[5] Venables [1982] considers a country that produces a homogenous good and differentiated goods but is a price taker on world markets and cannot export profitably. He characterizes the social optimum and notes that, in general, two policy instruments are needed to ensure that the optimal quantity and number of commodities are produced. His main purpose, however, is to derive optimal import tariffs. He finds that tariffs may increase welfare in this setting because they act as second-best instruments to correct domestic distortions and because they can alter the number of commodities imported. Gros [1987] emphasizes terms-of-trade effects and argues that even a small country is a unique supplier of its differentiated export good and thus can influence its external price. Flam and Helpman [1987] investigate a variety of industrial policies, including an output subsidy and an R&D subsidy. They emphasize that each policy has consequences for both the number of firms producing differentiated products and output per firm. Policies may have terms-of-trade implications as well. They conclude that intersectoral interactions and entry and exit opportunities in the differentiated-products industry weaken the case for policy intervention.

The model developed by Ethier [1979, 1982], which we adapt for the current analysis, is similar to Dixit-Stiglitz, but differs because variety matters to final-goods producers rather than to consumers. Ethier posits that the finished-manufactures sector experiences increasing returns in the number of intermediate input varieties, reflecting a greater division of labor. He refers to these economies as international returns to scale and notes that they do not require that all manufacturing output be concentrated in a single location. Ethier uses the model to describe the pattern of interindustry and intraindustry trade.

In the context of the Ethier model, Francois [1992] emphasizes the dependence of policy design on whether the benefits of increased scale are contained within national boundaries. He examines the justification for output subsidies to producers of differentiated inputs and emphasizes the effect of subsidization on the terms of trade.[6] With international trade in intermediates, he argues that the first-best policy for small countries operating on their own behalf is no subsidy. His reasoning is based on the inability of a small country to influence distortions arising at the final-good level because domestic intermediates producers are an insignificant share of world producers. In contrast, when intermediates are not traded, he argues that the first-best policy for a small country is an output subsidy that induces intermediates producers to price at marginal cost.

This paper, like Francois', emphasizes policy desigu but it shows that two instruments, an output subsidy and a lump-sum tax or subsidy, are needed for optimality. We begin with a description of the model. Next, we derive the conditions necessary for a social optimum, depict the *laissez-faire* equilibrium, and compare the scale of output and the number of intermediates produced in each instance. We derive the output subsidy and lump-sum policy needed to support the social optimum as a competitive equilibrium. Finally, we discuss the use of either an output or lump-sum subsidy when only one instrument is available.

3. THE MODEL

We employ a model, drawn from Ethier [1979,1982], of a small, open economy producing two final goods, "wheat" and finished "manufactures". Fixed supplies of capital and labor are intersectorally mobile and are allocated in competitive factor markets. Wheat is supplied by perfect competitors using capital and labor in a constant-returns-to-scale technology. Capital and labor may also be used, again in a constant-returns-to-scale technology, to produce "factor bundles" that serve as inputs into the production of intermediate goods, referred to as "components." In the final production stage, components are transformed into the finished manufactured good.

3.1 Factor Supplies and Technology

The fixed endowments of capital and labor, and the technology for producing wheat (W) and factor bundles (f) define a transformation function for the economy:

$$W = T(f) \ , \tag{1}$$

which may be represented by a familiar concave-to-the-origin production possibilities frontier, with $T'(f) < 0$ and $T''(f) \leq 0$. Competitive pricing for wheat and factor bundles implies that the relative price of factor bundles in terms of wheat, which serves as our numeraire throughout, is given by the opportunity cost

$$P_f = -T'(f) \ . \tag{2}$$

It is useful to summarize the elasticity of P_f with respect to f as

$$\varepsilon \equiv \frac{dP_f}{df}\frac{f}{P_f} = \frac{T''(f)f}{T'(f)} \geq 0 \ . \tag{3}$$

Turning now to the manufacturing sector of the economy, finished manufactures are costlessly assembled from intermediate goods according to the production function

$$M = n^{\alpha}\left[\sum_{i=1}^{n}\frac{x_i^{\beta}}{n}\right]^{\frac{1}{\beta}} , \tag{4}$$

where x_i is the input of intermediate component i into the production of manufactures, M. The production function (4) bas two features of note. First, components are imperfect substitutes; β $(0 < \beta < 1)$ measures the degree of "differentiation" as the elasticity of substitution between any pair of x_i is $1/(1-\beta)$. Higber values of β indicate easier substitution of components during assembly, hence less differentiation among the components.

The second feature of (4) is the role played by n, the number of differentiated components employed in manufactures. As written, α measures returns to diversity in intermediates, with $\alpha > 1$ indicating increasing returns. Hence, the production function embodies increases in output stemming from either greater scale (higher values of x_i) or greater diversity (larger values of n). One might think of the latter effect as indicating returns to more specialized domestic inputs, with the intermediates sector characterized by a variety of active firms. We assume that there are many intermediates producers, each of whom views n and total input demand in the M sector as fixed. Thus, while a greater variety of intermediate-producing firms has beneficial productivity effects, no single private agent has a direct interest in n, raising doubt as to whether a *laissez-faire* equilibrium will generate the appropriate degree of diversity.[7]

As in Ethier [1982] and Markusen [1989], we assume that all varieties of components have identical production technologies. Since each variety enters symmetrically into the production technology for finished manufactures, in equilibrium any produced variety will be produced in the common quantity, x. Thus, (4) collapses to

$$M = n^{\alpha}x \ . \tag{4a}$$

We see from (4a) that finished manufactures are linearly homogeneous in the scale of production, x, but homogeneous of degree α in n. These economies are external to the finished-manufactures industry as components are assembled into finished manufactures by many competitive firms, each of which takes n as given.

3.2 Pricing and Production Decisions

We assume that wheat and finished manufactures are tradeable; unlimited quantities of either final good may be purchased or sold at the relative price given by P_M. In contrast, intermediate components are not traded, thereby capturing the notion that it is the local intermediates sector that contributes uniquely to manufacturing productivity.[8]

Because components are imperfectly substitutable, each producer experiences some market power. However, there is free entry into each industry and we assume that component producers behave as monopolistic competitors, taking the behavior of other component producers as given.[9] The number of factor bundles required to produce x units of any variety is $ax + b$ $(a, b > 0)$, indicating returns to scale at the firm level. The parameter b defines the factor bundles that must be purchased prior to producing any single variety of components, with these fixed costs serving to limit the number of active intermediates producers in equilibrium. With n varieties of intermediate goods, the aggregate demand for factor bundles is $f = n(ax + b)$.

In analyzing production policies, we permit the government to affect both the marginal and fixed costs of producing components by providing factor bundles to the intermediate-goods sector. Specifically, the government may provide a lump-sum subsidy to each firm equal to G factor bundles, and an output subsidy of s factor bundles per unit of production of x. Note, however, that $G < 0$ and $s < 0$ are not precluded; the government may choose to levy fixed and output-based taxes on producers of components. In the presence of these policies, the per-firm demand for factor bundles is $(a\text{-}s)x + (b\text{-}G)$, at a private total cost of production equal to $P_f\{(a\text{-}s)x + (b\text{-}G)\}$. Note, however, there is an offsetting demand for factor bundles generated by government purchases of $sx + G$, leaving total bundles required to produce any variety unchanged at $ax + b$. We assume the availability of a lump-sum instrument to finance the purchase of factor bundles offered by the government to component producers.

Component producers equate marginal cost and marginal revenue, setting a price for each component of

$$q = \frac{P_f(a-s)}{\beta}. \tag{5}$$

Notice that as β rises, components become less differentiated, market power of each component producer declines, and the mark-up of price over marginal cost diminishes. Of the two policy instruments, only the output subsidy directly influences the market price of components. Given P_f, an increase in s reduces private marginal cost and thus q.

The profit, $qx - P_f((a-s)x + (b-G))$, of each firm supplying a component is driven to zero in equilibrium by free entry and exit. Employing the pricing rule of each firm (equation (5)) and the zero-profit condition, the scale of production for each component is

$$x = \frac{\beta(b-G)}{(1-\beta)(a-s)}. \tag{6}$$

It is useful to note that x is increasing in β; each firm produces more when its variety is more easily substituted by other varieties and hence faces greater competition. The two policy instruments have opposing effects on x: an increase in the lump-sum subsidy reduces output per firm while an increase in the output subsidy raises output per firm.

The price of finished manufactures is fixed by trade at P_M. Further, free entry implies zero profits in the assembly of components into manufactures, implying $P_M M = qxn$. Using the relationship $M = n^{\alpha}x$, the price of manufactures generates a demand price for components via

$$q = n^{\alpha-1}P_M\ . \tag{7}$$

Note that an increase in n raises productivity and, therefore, permits a higher price for component producers. However, the reverse is true as well: higher prices for components may be sustained in equilibrium only by an increase in the number of varieties produced.

4. FIRST-BEST DIVERSITY AND SCALE

What are the socially preferred values for intermediates scale and diversity, x and n? If domestic welfare depends upon aggregate consumption of wheat and finished manufactures, $U=U(C_W,C_M)$, domestic consumers will equate the domestic rate of substitution in consumption with world relative prices: $U_M/U_W = P_M$. Hence, welfare-improving policies are those that expand the value of domestic production at world prices and, thus, the resources available for consumption.

A social planner would maximize welfare by choosing x and n to maximize

$$P_M n^{\alpha} x + T(f), \tag{8}$$

where $f = n(ax + b)$. Optimal values are characterized by the first-order conditions

$$P_M n^{\alpha} = -T'(f) na \tag{9a}$$

and

$$\alpha P_M n^{\alpha-1} x = -T'(f)(ax+b) . \tag{9b}$$

Equation (9a) characterizes the optimal scale of component production, x, obtained by equating the additional manufacturing output gained by increasing x with the marginal resource cost (measured in foregone wheat, or the social cost of factor bundles) of expanding the scale of each variety by the same increment. Similarly, equation (9b) characterizes the optimal diversity of components. The right side is the resource cost of introducing a new variety of component, while the left side indicates the value of additional manufacturing output that derives from the new variety. Notice that if $\alpha=1$, the latter is simply $P_M x$. In the presence of returns to diversity, however, manufacturing output rises by a larger amount when another specialized input is introduced.

Substituting (9a) into (9b) and solving yields the optimal scale of production for each variety:

$$x^* = \frac{b}{(\alpha - 1)a} \tag{10}$$

where the superscript "*" denotes optimal values. The optimal scale depends on the ratio of fixed to marginal costs, with marginal costs weighted by α-1, the rate at which the economy realizes the external economy. The larger this rate is, the smaller the optimal scale for each firm. The implied per-firm use of factor bundles is

$$ax^{*} + b = \frac{\alpha b}{\alpha - 1} \quad , \tag{11}$$

which is easily shown to be a decreasing function of α. Finally, using (9a), the optimal diversity of components is implicitly defined by

$$n^{*} = \left[\frac{-T'(f^{*})a}{P_M} \right]^{\frac{1}{\alpha-1}} \quad . \tag{12}$$

5. LAISSEZ-FAIRE EQUILIBRIUM AND ITS WELFARE PROPERTIES

5.1 Equilibrium

We compute the competitive equilibrium in the absence of government intervention by setting $s=G=0$. From (6), equilibrium scale for each variety of components is

$$x^{e} = \frac{\beta b}{(1-\beta)a} \; , \tag{13}$$

where the superscript "e" denotes an equilibrium value. The greater the extent of each differentiated-input producer's market power, the lower is output per firm. Demand for factor bundles by each producer is

$$ax^{e} + b = \frac{b}{1-\beta} \quad . \tag{14}$$

Aggregating demands for factor bundles from all producers of components yields the equilibrium price of factor bundles

$$P_f^e = -T'(f^e) = -T'(n^e(ax^e+b)) = -T'(\frac{n^e b}{1-\beta}) \quad . \tag{15}$$

Producers of components set prices above marginal cost, using a markup of $1/\beta$. Hence, in equilibrium components are priced according to

$$q^e = \frac{-T'(f^e)a}{\beta}. \tag{16}$$

Recall, however, that prices charged by producers of components are constrained by the demand price of producers of finished manufactures (see (7)). Hence, the equilibrium must satisfy

$$P_M(n^e)^{\alpha-1} = \frac{-T'(f^e)a}{\beta} \quad , \tag{17}$$

or

$$n^e = \left[\frac{-T'(f^e)a}{P_M\beta}\right]^{\frac{1}{\alpha-1}} \quad . \tag{18}$$

With equilibrium production of each variety set by equation (13), f^e depends only upon n^e. Hence, equation (18) determines the number of varieties produced in equilibrium.

An interesting feature of the model is that the aggregate demand curve for factor bundles is upward-sloping. Output per firm is unaffected by P_f, while the number of intermediates rises with P_f (see (18)). Hence, aggregate demand for $f = n(ax + b)$ rises with P_f. Stability in the market for factor bundles requires that the slope of the supply curve (given by $P_f = -T'(f)$) exceed the slope of the demand curve, or $\varepsilon > \alpha - 1$.

The degree of market power affects the number of varieties in two ways. First, greater market power (smaller β) implies a higher price of components and, holding P_f fixed, necessitates a larger number of firms to maintain zero profits in finished manufactures assembly. However, P_f is also affected by β (greater market power, smaller per-firm output and lower price for factor bundles) and by changes in n (more firms, higher price for factor bundles). It can be shown that greater market power for each components producer implies a greater number of active firms if $\varepsilon > (1-\beta)/\beta$. This condition ensures that q^e is an decreasing function of β, and thus that n must be larger when input differentiation is greater.

5.2 Welfare Properties

We begin our exploration of the efficiency properties of the competitive equilibrium by examining the scale of production for each producer of components. Comparing equations (13) and (10) one finds that the competitive equilibrium may generate either inefficiently small or inefficiently large output of each variety. Specifically,

$$x^e \gtrless x^* \quad as \quad \alpha - 1 \gtrless \frac{1-\beta}{\beta} . \tag{19}$$

Here, α-1 represents the rate at which returns to diversity are realized in the economy (see Ethier [1982]). $(1-\beta)/\beta$ is the markup over marginal cost (as a percentage of marginal cost), which is used to cover fixed costs for each variety. Hence, it represents the rate at which individual firms are able to appropriate the surplus generated by returns to diversity. Efficient production of each variety occurs only if firms appropriate the surplus from each variety at exactly the same rate as it is generated in the economy.

We turn now to the issue of whether the *laissez-faire* equilibrium provides sufficient varieties of intermediate products. Equations (18) and (12) provide the framework for examining the relationship between n and x in the *laissez-faire* equilibrium and the first-best allocation. These relationships are graphed in Figure 1, which shows the orderings of x^e and x^* and n^e and n^* for possible values of the return to diversity (α - *1*) and percentage markup $(\frac{1-\beta}{\beta})$. [10]

As the figure makes transparent, the degree to which the *laissez-faire* equilibrium over- or under-provides diversity of intermediate components is intimately linked to the relationship between x^e and x^*. As a benchmark, consider the case in which $x^e = x^*$; i.e., points along the diagonal in Figure 1. Here $n^e < n^*$; while the market provides the right amount of each differentiated input, it provides too few varieties of inputs.[11] The reason for the underprovision of input varieties is that finished manufactures assemblers are charged a markup over the marginal cost dictated by the factor-bundle content of components. Rearranging equation (18) yields

$$P_M = \frac{1}{\beta} \frac{-T'(f^e)\,a}{(n^e)^{\alpha-1}} \quad . \tag{20}$$

The left side of this expression is the world price of manufactures, which also constrains production relationships in the first-best equilibrium. The right side, however, is distinguished by the markup of $1/\beta$. The remainder of the right-side expression is an increasing function of n. Thus, for the expression to hold in the *laissez-faire* equilibrium when $x^e = x^*$, n^e must be less than n^*. With the price of manufactures fixed by world markets, the domestic economy must adjust to mark-up pricing of components by reducing the production of varieties, the demand for components, and thus the cost of components.

However, a wider range of outcomes is possible. Returning to Figure 1, note that in any instance when $x^e > x^*$, $n^e < n^*$. That is, inefficiently large production of each component is associated with inadequate diversity of inputs. Essentially, for a given return to diversity (α-1) the market meets competitive pressure on P_M by producing too few varieties and hence lowering demand for factor bundles. The first-best would require sacrificing output per component firm, increasing the number of varieties, and meeting competitive pressure through exploiting the return to diversity.

As shown in the figure, however, the picture is less clear when $x^e < x^*$. Again, consider a specific value of α-1. As the percentage markup rises (and β declines), initially n^e remains below the first-best. Eventually, however, the equilibrium is characterized by too little output per component firm and excessive reliance on returns to diversity in order to meet the world price of finished manufactures.

6. DECENTRALIZING THE SOCIAL OPTIMUM

It is straightforward to design policies that support the first-best outcome as a competitive equilibrium. Equation (9a) may be interpreted as a first-best rule for pricing of components; that is

$$q^{*} \equiv P_M(n^{*})^{\alpha-1} = -T'(f^{*})a \qquad (21)$$

indicating that components should be priced at their social marginal cost. Assume temporarily that $x^e = x^*$. A comparison of (12) and (18) indicates that the number of firms will be correct if components are priced at marginal cost; that is, $n^e = n^*$ if $\frac{a-s}{\beta} = a$. This suggests an optimal subsidy of $s^* = (1-\beta)a$. Under these circumstances, the post-subsidy marginal cost is $P_f(a-s^*) = P_f \beta a$, which is "marked-up" by $1/\beta$ to yield marginal cost pricing.

Is it possible to have $x^e = x^*$? Substituting the optimal subsidy into (6), equating (6) with (10) and solving for G yields

$$G^{*} = b\left(1 - \frac{(1-\beta)}{(\alpha-1)}\right). \qquad (22)$$

The sign of G^* is dictated by the relationship between post-subsidy x^e and x^*. Specifically, after receiving the production-based subsidy the scale of activity for each component producer is related to the first-best according to

$$x^{e} = \frac{b}{(1-\beta)a} \gtrless x^{*} = \frac{b}{(\alpha-1)a} \quad as \quad (\alpha-1) \gtrless (1-\beta) \qquad (23)$$

which relates directly to the conditions under which G^* is employed to raise ($G^* < 0$) or lower ($G^* > 0$) output per firm in the intermediate sector.[12]

The existence of fixed production costs (b) dictates the need for the producer of each variety to price above marginal cost. At a heuristic level, one might suspect that the optimal production policy would eliminate fixed costs in order to permit marginal cost pricing.

Computing the subsidy (in factor bundles) per firm yields: $s^*x^* + G^* = b$. Hence, the optimal policy indeed eliminates fixed costs.

Importantly, however, the policies do not directly eliminate fixed costs as $G^* \neq b$. Instead, the optimal subsidy, s^*, must be positive to correct markup pricing. In turn, G^* will be negative if $s^*x^* > b$. Using the expressions for s^* and x^*,

$$G^* \gtrless 0 \quad as \quad (\alpha-1) \gtrless (1-\beta) \quad . \tag{24}$$

Optimal production policies may call for lump-sum *taxes* upon intermediate producers. Such taxes raise fixed costs for producers and, recalling (6), serve to raise the x necessary to break even.

Using s^* and G^*, the scale of production of each component will achieve the first-best, each variety of component will be priced equal to its marginal production cost, and the diversity of components will be chosen to maximize output subject to the price pressures generated by trade in finished manufactures. Thus, the availability of two policy instruments is critical to achieving efficient production.

Francois [1992] also examines optimal policies in the context of firm-level returns to scale and industry-level returns to variety. He proposes $s^*=(1-\beta)a$ as the optimal commercial policy when intermediates are nontraded, implicitly setting $G=0$. In the Francois version of the model, the aggregate production function for finished manufactures is written in such a way that (in our notation) $\alpha = 1/\beta$.[13] Thus, the market equilibrium achieves the first-best output per firm. Francois suggests an output subsidy of $(1-\beta)a$ to ensure that firms price at marginal cost. Recalling (18), this subsidy will lead to the socially efficient number of varieties for a *given* scale of production per variety. However, Francois ignores the effect this subsidy will have on output per firm. Using expression (6), we can see that the output subsidy will raise output per firm above its socially optimal level.

Optimality in the Francois formulation requires an output subsidy of $(1-\beta)a$ coupled with a lump-sum subsidy of $b(1-\beta)$. By employing a lump-sum subsidy, the government may alter not only pricing but also the private fixed costs of production, the break-even scale of production, and incentives to enter or exit production of new varieties.[14]

7. OPTIMAL POLICY WITH LIMITED INSTRUMENTS

Implementation of first-best policies is a formidable task. While, it is straightforward to develop a "rule" for s^* — provide subsidies sufficient to induce marginal-cost pricing — the moral of Figure 1 is clear: designing the appropriate fixed tax/subsidy depends upon a sophisticated knowledge of the ordering of *laissez-faire* and optimal diversity.

As noted above, total subsidies to the firm should precisely compensate for fixed costs. Hence, a "rule" for G^* is to subsidize any remaining fixed costs, or tax away any surplus. In practice, however, even this guideline requires a sophisticated understanding of firms' cost structures and output decisions.

Given these difficulties, one might be tempted to avoid use of G altogether, and restrict policies to the use of output-based subsidies. As emphasized above, however, using a single instrument does not permit one to control both x and n and reach the efficient production plan. Instead, the second-best subsidy rate, s', must balance the relative benefits of altering scale and diversity. A subsidy that eliminates markup pricing ($s'=a(1-\beta)$) does not in general achieve the first-best level of output.[15] Similarly, setting s' to achieve x^* does not provide for efficient pricing, and hence diversity.[16] As a result, the optimal subsidy when G is constrained to zero is below a, but may be negative.[17]

An alternative strategy toward the policy problem is to avoid use of direct subsidies, instead employing policy toward exit and entry to guide competitive pressures. In this light, interpret the choice of G as a policy toward entry and exit in the industry. Our discussion above indicates that the use of entry policy in isolation will not be sufficient to achieve the efficient production policy. The second-best value of G, denoted G', is

$$G' = b\left[\frac{\varepsilon(1+\beta+\alpha\beta)-(\alpha-1)(1-\beta)}{\varepsilon(2-\alpha)-\alpha(1-\beta)}\right] \tag{25}$$

As with the second-best s', it is not in general feasible to determine the sign of the second-best fixed tax/subsidy, casting doubt upon the ease of developing administrable guidelines for policies of this type.

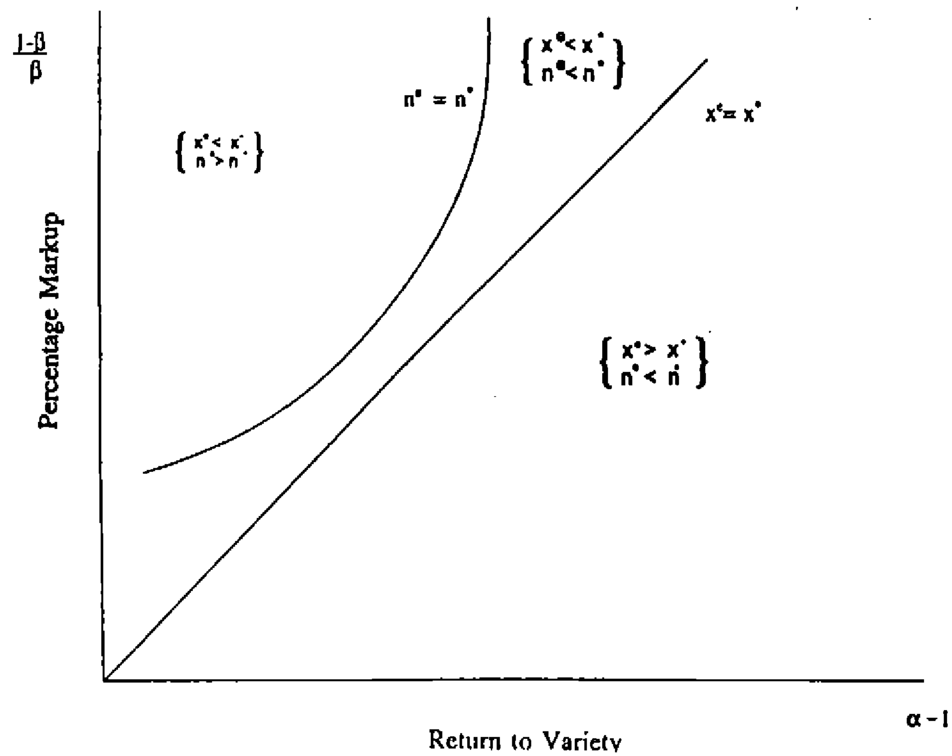
8. SUMMARY

The existence of firm-level economies of scale suggests the "commonsense" solution of subsidizing firms to exploit these scale economies. In the presence of additional national-level returns to variety, the weight of evidence in favor of policies to reduce fixed costs appears even greater. Our investigation of optimal policies toward intermediate-good production suggests that the actual design of these industrial policies is far from straightforward. First-best policies eliminate fixed costs, but the interaction between scale and diversity leads to a mix of lump-sum and output subsidies, and may even involve lump-sum taxes on firms. Further, access to two separate policy instruments is crucial. In the absence of either instrument, the optimal second-best policy may not be a subsidy at all.

Laissez faire may yield either too few or too many varieties of intermediate goods. It may also lead to either over- or under-exploitation of internal scale economies. Thus, as in other contexts, there can be no presumption that a monopolistically competitive intermediates sector restricts output below the socially optimal level nor that it produces too many varieties. To intervene productively, policy makers need information on market structure as well as technological relationships. Providing adequate empirical support for industrial policy decisions remains a formidable challenge.

LAISSEZ-FAIRE VERSUS FIRST-BEST SCALE AND DIVERSITY

FIGURE 1



Notes

1. These policy issues have been raised in the context of investment in new technologies. In a discussion of the "Economics of Appropriability," the *1994 Economic Report of the President* (pp.190-1) notes that "... The most important innovations generate spillover benefits for interconnected sectors, creating economic gains well beyond any that eventually accrue to their inventors. ...public actions can offset the effects of underinvestment by the private sector that is caused by limitations on appropriability."

   Similar arguments have been raised concerning spillovers from other types of investment. For example, the Clinton Administration recently received front-page coverage by endorsing a $1 billion proposal to assist the American advanced flat-panel computer-display screen industry. At least in part, the rationale for such a subsidy rests on the belief that a larger domestic intermediate-good industry will raise productivity of final-good producers. As reported in *The New York Times*, computer screens were chosen for assistance because of their defense uses and because of concerns that the lack of a display-screen industry could weaken the American telecommunications and computer industries [Bradsher, 1994].

2. Markusen [1991] uses a similar structure in which the intermediates are described as nontraded business services. Markusen [1989] shows that when scale economies in final manufactures depend on the number of input varieties produced worldwide, there are gains from trade in these inputs.

3. The standard reference on national versus international returns to scale is Ethier [1982]. Francois [1992] emphasizes terms-of-trade effects in policy design. A large and diverse literature on international propagation of diseconomies of scale also exists, particularly in reference to global environmental issues.

4. Tirole [1988, pp. 298-300] provides an overview of the Dixit-Stiglitz model and its normative properties.

5. Krugman [1990] provides an overview of developments in the modelling of trade in differentiated products.

6. Markusen [1990] shows that a small tariff may reduce the number of domestic inputs enough that domestic welfare falls.

7. One need not interpret the terms "components" and "assembly" literally. Instead, the structure is intended to embody the reliance of final-goods manufacturing on a wide variety of specialized business services and products as inputs. In other studies, these components have been interpreted in several ways. Ethier [1982] emphasizes specialized intermediate inputs. He intends to capture, via the endogenous determination of the number of component varieties, the possibility of returns to scale arising from the division of labor. He notes that, alternatively, one could interpret the intermediate goods as successive manufacturing stages. Markusen [1989] interprets the intermediate goods as producer services that are knowledge-intensive, requiring a high initial investment in learning.

8. Ethier [1979,1982] assumes components are traded, emphasizing division of labor that depends on the size of the world market rather than upon the geographical concentration of the industry. Markusen [1991] assumes that intermediates are nontradeable, identifying them as knowledge-based, specialized business services. Markusen argues that such services are costly to trade internationally or face high tariff barriers.

9. As is standard, we assume that n is "large" and we ignore any integer constraint placed on n.

10. The figure reflects $\varepsilon > \alpha-1$ and $\varepsilon > \frac{1-\beta}{\beta}$. In the language of Ethier [1982], ε is the "intersectoral effect," while α is the "scale effect." For the planning problem, $\varepsilon > \alpha - 1$ is necessary for the second-order condition to hold. In the market economy, the same condition implies stability in the market for factor bundles. The restriction on the relative size of ε and β ensures that $n^e = n^*$ locus is upward sloping. As noted in the text, this restriction implies that q^e is a decreasing function of β and, hence, that n^e is a decreasing function of β. The condition thus ensures that n^e rises as the markup rises.

11. As noted earlier, Dixit and Stiglitz [1977] examine similar issues in the context of the provision of varieties of consumer goods. In the circumstances that most closely parallel this investigation (the constant-elasticity case), they find that the *laissez-faire* equilibrium generates efficient scale, but insufficient diversity. In their model, the same parameter determines substitutability (and, thus, markup) and the value to consumers of additional variety.

12. Note that in Francois' version of the model, G^* is unambiguously positive because the formulation ensures that $x^e = x^*$.

13. The aggregate production function for manufactures used by Francois [1992] is identical to that used by Markusen [1989].

14. This result is reminiscent of Carlton and Loury [1980] who examine optimal control of a detrimental production externality. Pigouvian taxes "solve" the problem of external costs and induce efficient production per firm in the short run. However, by altering the cost structure of firms, they may also induce entry or exit into the industry, and lead to inefficient aggregate emissions of the externality. Carlton and Loury propose a fixed tax/subsidy in addition to an output tax to control not only output per firm, but also the number of firms.

15. In the presence of s', output of each variety is $x^e = \frac{b}{(1-\beta)a} \neq x^* = \frac{b}{(\alpha-1)a}$.

16. Setting s' to reach x^* results in $q = P_f(\frac{\alpha-1}{1-\beta})a \neq P_f a$.

17. It is not possible to derive a closed-form expression for s'. Details of the analysis of s' are available from the authors.

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