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INDUSTRIAL POLICY UNDER MONOPOLISTIC COMPETITION

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Harry Flam and Elhanan Helpman

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FOERDER INSTITUTE FOR ECONOMIC RESEARCH
Faculty of Social Sciences, Tel-Aviv University
Ramat Aviv, I s r a e l.

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1. Introduction

The debate about the desirability of industrial policies has expanded in recent years from policy practitioners to the academic community, generating a growing theoretical literature on the subject. True, some of the issues involved in this debate are not new: they have appeared in various forms time and again since the publication of Frank Graham's famous argument for tariff protection for industries that operate under increasing returns scale, beginning with the debate that developed between him and Frank Knight in 1924-1925 (see Graham (1923,1925) and Knight (1924,1925)). However, never before has this debate generated a crop of new arguments that seem to have a theoretical underpinning as it has in recent years. The power of the new arguments for tariff protection, export promotion and R and D subsidies lies to a large extent in the fact they have been presented in a simple and transparent way which makes their theoretical underpinning accessible to experts and nonexperts alike. Unfortunately, the very features that have made them popular carry also their major weaknesses, because the simple models within which they have been cast abstract from important general equilibrium interactions and aspects of industrial structure whose presence may not only weaken the arguments, but can also change them fundamentally.

It is rather obvious that in an economic environment in which firms and industries operate under increasing returns to scale and exhibit noncompetitive behavior there exists room for beneficial intervention. It is, therefore, not surprising to find in a model of this nature that a particular policy, of one type or other, that is harmful in a competitive environment is beneficial in this environment. However, the important question is not whether one can find a policy that works in a particular setup (unless the entire setup is of practical relevance), but rather whether the particular policy is beneficial in all or most relevant environments, or alternatively, what are the observable characteristics of an economic environment in which this policy will be beneficial.

The most powerful criticism of the new arguments for tariff protection and export promotion have been advanced by Dixit (1984), Eaton and Grossman (1983) and Dixit and Grossman (1984) along two main lines: general equilibrium considerations and the nature of imperfect competition. They have pointed out that the Brander and Spencer (1984) result on the desirability of a tariff as a strategic instrument, that enables a country to extract monopoly rents from foreign firms that interact with domestic firms in an oligopolistic market, rests heavily on the absence of other noncompetitive industries that interact with the oligopolistic industry in factor markets, and that the strength of the argument depends on the degree of entry competition. The same criticism applies also to a similar result reported in Feenstra and Judd (1982) for an economy with a monopolistically competitive sector. Eaton and Grossman have also shown that the Brander and Spencer (1985) result about the desirability of an export subsidy in an oligopolistic industry, that enables a subsidizing economy to slide down the foreigners' reaction function, thereby gaining a position that is closer to that of a Stackelberg leader, depends on the assumptiom that firms play a Cournot quantity game. If they play a Bertrand price game the result is reversed -- an export tax becomes beneficial. And if they have consistent conjectures then free trade is the optimal policy..

It is clear from these examples that the nature of beneficial policies depends in important ways on economic structure and the nature of competition. It is, therefore, desirable to examine their applicability in a variety of environments that are believed to be relevant. Since industries that produce differentiated products under increasing returns to scale and in which firms engage in monopolistic or oligopolistic competition are prevelent in the industrial countries as well as in the newly industrialized countries, a study of this type of an environment seems most appropriate. For this purpose we develop in this paper a model of a small country that produces homogeneous as well as differentiated products and engages in research and development in the differentiated product industry. Varieties of the differentiated product are produced with increasing returns to scale that result from the existence of R and D costs. We allow for a resonable general production structure and consider in this framework the effects of a tariff, an export subsidy, an output subsidy and an R and D subsidy. This menu of policy instruments is widely used in many countries. We study the effects of these policies on resource allocation and welfare. The major conclusion from our analysis is that the allocative effects of these policies are reasonably insensitive to the production structure as long as they are applied in small doses (although exceptions to this rule do exist), but that their welfare consequences do depend on the details of production structure and preferences except for a small tariff which is always welfare improving. However, our tariff result can be subjected to the Dixit-Grossman criticism of the Brander-Spencer tariff result and it is, therefore, not robust. Thus, an export subsidy, an output subsidy and an R and D subsidy may be welfare reducing.

Our model is developed in Section 2. Then, in Section 3 we analyze the allocative effects of all four policy instruments. Welfare implications of these policies are discussed in Section 4 and conclusions are drawn in Section 5.

2. The model

In this section we describe the economic environment within which we will examine the effects of industrial policies. It is assumed that goods can be conveniently divided into two categories; a homogeneous product Y that is produced with constant returns to scale and a differentiated product X that is produced with increasing returns to scale. We consider a country whose representative individual has a utility function

$$(1) \qquad U = u_X^{\alpha} d_Y^{1-\alpha}$$

where d_Y is consumption of Y and u_X is the subutility level derived from the consumption of the available varieties of the differentiated product. It is assumed that u_X has the Spence-Dixit-Stiglitz form of a constant elasticity of substitution function. We distinguish between varieties that are domestically produced and imported varieties. The number of the former is n and the number of the latter is n^*. The elasticity of substitution σ is the same for every pair, independently of its origin. In particular:

$$(2)\qquad u_X = \left[\Sigma_{i=1}^{n} d_i^{(1-\frac{1}{\sigma})} + \Sigma_{i=1}^{n^*} d_{fi}^{(1-\frac{1}{\sigma})}\right]^{\frac{1}{(1-\frac{1}{\sigma})}} \quad , \sigma > 1$$

where d_i is consumption of the domestically produced variety i and d_{fi} is consumption of imported variety i. It is well known that this demand structure yields the following demand functions for differentiated products (see, for example, Helpman and Krugman (1985, ch.6)):

$$(3a)\qquad d_i = \frac{p_i^{-\sigma}}{\Sigma_{j=1}^{n} p_j^{1-\sigma} + \Sigma_{j=1}^{n^*} p_{fj}^{1-\sigma}} \alpha E \quad , i = 1,2,\ldots,n$$

$$(3b)\qquad d_{fi} = \frac{p_{fi}^{-\sigma}}{\Sigma_{j=1}^{n} p_j^{1-\sigma} + \Sigma_{j=1}^{n^*} p_{fj}^{1-\sigma}} \alpha E \quad , i = 1,2,\ldots,n^*$$

where p_i is the consumer price of the domestically produced variety i; p_{fi} is the consumer price of the imported variety i; and E is the country's total spending in terms of Y, which we assume is equal to its income (αE is spending on varieties of X). The homogeneous good is chosen to be the numeraire; i.e., $p_Y = 1$.

Foreign demand for domestic varieties is assumed to be derived from preferences in which (2) describes the subutility of consumption of differentiated products. Hence, foreign demand for home variety i is:

$$(3c) \qquad d_i^* = \frac{p_{hi}^{-\sigma}}{\Sigma_{j=1}^{n} p_{hj}^{1-\sigma} + \Sigma_{j=1}^{n^*} p_j^{*1-\sigma}} E_X^*, \quad i = 1,2,\ldots,n$$

where p_{hi} is the foreign consumer price of home variety i; p_j^* is the foreign consumer price of foreign variety i; and E_X^* is foreign spending in terms of Y on differentiated products.

We assume the existence of free trade in Y, so that $p_Y = p_Y^* = 1$. We also assume that foreign varieties are equally priced, with units conveniently chosen so that:

$$p_i^* = 1, \quad i = 1,2,\ldots, n^*$$

Moreover, our country is small, implying that it faces a given foreign price of the homogeneous product, given foreign spending on differentiated products, a given number of foreign varieties of the differentiated product, and a given foreign price of the differentiated product. Shifts in excess demands of the small country do not affect these variables. This implies:

$$p_{fi} = (1+t)p_i^* = 1+t, \quad i = 1,2,\ldots,n^*$$

where t is the tariff rate on imports of differentiated products.

Despite the small size of the country it is assumed that home firms in the differentiated product industry are facing downward sloping foreign demand functions as described by (3c). Moreover, given home country export subsidies on these products at the rate e, foreign consumers face prices:

$$p_{hi} = p_i/(1+e), \quad i = 1,2,\ldots,n$$

The above described price relationships imply:

$$\text{(3'a)} \qquad d_i = \frac{p_i^{-\sigma}}{\Sigma_{j=1}^{n} p_j^{1-\sigma} + n^*(1+t)^{1-\sigma}} \alpha E \quad , \quad i = 1,2,\ldots,n$$

$$\text{(3'b)} \qquad d_{fi} = \frac{(1+t)^{-\sigma}}{\Sigma_{j=1}^{n} p_j^{1-\sigma} + n^*(1+t)^{1-\sigma}} \alpha E \quad , \quad i = 1,2,\ldots,n^*$$

$$\text{(3'c)} \qquad d_i^* = \frac{[p_i/(1+e)]^{-\sigma}}{\Sigma_{j=1}^{n} [p_j/(1+e)]^{1-\sigma} + n^*} E_X^* \quad , \quad i = 1,2,\ldots,n$$

The home producer of variety i faces the demand function $d_i + d_i^*$, where d_i and d_i^* are taken from (3'a) and (3'c), respectively. Given a large number of varieties, the producer is facing an approximately constant elasticity of demand $\sigma > 1$. It is assumed that he treats σ as the exact demand elasticity, which corresponds to disregarding the effects of his price change on the denominator in (3'a) and (3'c). Now, firms in sector X are engaged in monopolistic competition. Therefore, each firm equates marginal revenue to marginal cost. In the presence of a production subsidy at the rate z the subsidy becomes part of marginal revenue implying:

$$(1+z)p(1 - \frac{1}{\sigma}) = MC.$$

We assume that every variety is produced with the same cost structure. There are R and D (research and development) costs $c_n(w)$

incurred in product development, where w is the vector of factor rewards, and constant production costs per unit output $c(w)$. Hence, total production costs for x units of a variety are:

$$c_n(w) + c(w)x.$$

Since we consider a one-period horizon, we assume for convenience that all n products are new products which require R and D (we will comment at a later stage on the possibility of having some varieties developed in the past, so that current costs for these varieties are only production costs). Given this cost structure the equating of marginal revenue to marginal cost implies:

$$(1+z)p_i(1-1/\sigma) = c(w), \quad i = 1,2,\dots,n.$$

Hence, all home varietes are equally priced; i.e., $p_i = p$, and produced in the same quantity; i.e., $x_i = d_i + d_i^* = d + d^* = x$. Moreover, given the free entry profits are driven down to zero. This means that operating profits π cover the fixed costs. Given an R and D subsidy at the rate s this implies:

$$(1-s)c_n(w) = \pi.$$

Now, assuming that production takes place in both sectors, we obtain the following pricing relationships:

(4a) $$c_Y(w) = 1$$

(4b) $$c(w) = (1+z)Mp$$

(4c) $\qquad c_n(w) = \pi/(1-s)$.

The first one describes marginal cost pricing of the homogeneous product. The second one describes markup pricing of differentiated products, where

$$M = 1 - 1/\sigma.$$

The last one describes competitive (marginal cost) pricing of R and D. We assume that R and D is not traded internationally. It seems in fact reasonable to assume in our context that every firm in the differentiated product sector has to perform its own product development in order to be able to differentiate it from other products. Our formulation covers this case as well as the case in which R and D is traded within national borders as long as it is not traded internationally.

The equilibrium conditions in factor markets can now be represented by:

(5) $\qquad a_Y(w)Y + a(w)X + a_n(w)n = V$

where V is the vector of factor endowments; Y is the output level in the homogeneous product sector; $X \equiv nx$ is the output level in the differentiated product sector; $a_Y(w) \equiv \nabla c_Y(w)$ is the gradient of $c_Y(w)$ which is equal to the vector of inputs per unit output of Y; $a(w) \equiv \nabla c(w)$ is the vector of inputs per unit output of x; and $a_n(w) \equiv \nabla c_n(w)$ is the vector of inputs per unit output of R and D.

Conditions (4) and (5) imply that the country's income can be represented by a revenue (profit) function $R[(1+z)Mp, \pi/(1-s); V]$, so that:

$$E = R[(1+z)Mp,\ \pi/(1-s);\ V] + T \tag{6}$$

where T is the net tax rebate resulting from the government's policy. The function $R(\cdot)$ is convex in the first two arguments; concave in V; and positively linear homogeneous in V. Moreover, its partial derivatives with respect to the first two arguments (assumed to exist) equal the output levels of X and of R and D respectively:

$$nx = R_1[(1+z)Mp,\ \pi/(1-s);V] \tag{7}$$

$$n = R_2[(1+z)Mp,\ \pi/(1-s);\ V]. \tag{8}$$

We discussed this derivation under the assumption that all n varieties are new. However, the current representation applies also to cases in which some varieties or all of them were developed in the past or are an endowment from nature. If there exists a predetermined number of varieties $\bar{n}$ then the revenue function can be written as:

$$R[(1+z)Mp,\ \pi/(1-s);V] \equiv \tilde{R}[(1+z)Mp,\ \pi/(1-s);V] + \bar{n}\pi/(1-s)$$

where $\tilde{R}(\cdot)$ is the revenue function derived from the production activities. If no new products can be developed, $\tilde{R}(\cdot)$ does not depend on $\pi/(1-s)$.

The demand functions (3'a) and (3'c), slightly rewritten to take account of identical prices on domestic differentiated products, imply also the equilibrium condition $(d_i + d_i^* = x_i)$:

$$(9) \qquad px = \frac{p^{1-\sigma}}{np^{1-\sigma} + n^{*}(1+t)^{1-\sigma}}\alpha E + (1+e)\frac{[p/(1+e)]^{1-\sigma}}{n[p/(1+e)]^{1-\sigma} + n^{*}}E_X^{*}.$$

In order to complete the description of the equilibrium conditions we need to define π and T. Operating profits are:

$$\pi = [(1+z)p - c(w)]x$$

which implies by means of (4b) (remember that $M = 1 - 1/\sigma$):

$$(10) \qquad \pi = (1+z)px/\sigma.$$

Hence, operating profits are a constant share ($1/\sigma$) of revenue, inclusive of the output subsidy. This stems from the fact that firms engage in constant markup pricing. Net taxes collected by the government, which are then redistributed to the private sector, are given by:

$$(11) \qquad T = tp^{*}n^{*}d_f - ep_h nd^{*} - zpnx - sc_n(w)n.$$

Using (3'b), (3'c), (4c), (10) and (11), condition (6) can be written as:

$$(12) \qquad E = R[(1+z)Mp, \pi/(1-s);V] + \frac{t}{1+t}\cdot\frac{n^{*}(1+t)^{1-\sigma}}{np^{1-\sigma} + n^{*}(1+t)^{1-\sigma}}\alpha E$$

$$- e\frac{n[p/(1+e)]^{1-\sigma}}{n[p/(1+e)]^{1-\sigma}+n^{*}}E_X^{*} - z\frac{\sigma\pi n}{1+z} - s\frac{\pi n}{1-s}$$

Our reduced form equilibrium conditions consist of equations (7), (8), (9), (10), and (12). They describe implicit solutions for the number of products n, output per product x, the relative consumer price of the domestic differentiated products p, operating profits per firm π, which equal R and D expenditure, and total spending in terms of the numeraire E. We will use this representation in order to derive the effects of commercial and industrial policies on resource allocation and welfare.

3. Resource allocation

We study in this section the effects of various policies on resource allocation. The results of this analysis are of interest in their own right and they are also required for a welfare evaluation of these policies that will be undertaken in the next section. We consider the application of four policy instruments in the differentiated product sector: a tariff, an export subsidy, an output subsidy and an R and D subsidy. All these policies are common practice in the manufacturing sector of many countries. Since a general analysis of these policies is very messy, we consider the effects of "small" doses of these policy instruments.

Logarithmic differentiation of (7)-(10) and (12) at the free trade point (t, e, z, s) = (0,0,0,0) yields

$$\hat{n} - \varepsilon_{12}\hat{\pi} - \varepsilon_{11}\hat{p} + \hat{x} = \varepsilon_{11}dz + \varepsilon_{12}ds \tag{13}$$

$$\hat{n} - \varepsilon_{22}\hat{\pi} - \varepsilon_{21}\hat{p} = \varepsilon_{21}dz + \varepsilon_{22}ds \tag{14}$$

$$\alpha_x\hat{n} + [\alpha_x + (1-\alpha_x)\sigma]\hat{p} - \gamma\hat{E} + \hat{x} = \gamma(1-\alpha_x)(\sigma-1)dt + (1-\gamma)[\alpha_x + (1-\alpha_x)\sigma]de \tag{15}$$

$$\hat{\pi} - \hat{p} - \hat{x} = dz \tag{16}$$

(17) $$S_n\hat{\pi} + S_x\hat{p} - \hat{E} = -\frac{m}{E}dt + \frac{b}{E}de$$

where

$\hat{\pi}$ = $d\pi/\pi$, the proportional rate of change of operating profits, and R and D expenditure. Similarly for n, p, x and E.

S_n = $\pi n/R$, the share of R and D in GDP which equals also to the share of operating profits in GDP.

S_x = pX/R, the share of differentiated products in GDP.

b = $p_h n d^*$, export value of differentiated products.

m = $p^* n^* d_f$, import value of differentiated products.

ε_{11} = $(R_{11}/R_1)pM$, the sectoral elasticity of supply of differentiated products with respect to marginal revenue.

ε_{12} = $(R_{12}/R_1)\pi$, the elasticity of supply of differentiated products with respect to operating profits.

ε_{22} = $(R_{22}/R_2)\pi$, the elasticity of supply of the number of varietes (R and D output) with respect to operating profits.

ε_{21} = $(R_{21}/R_2)pM$, the elasticity of supply of the number of varieties (R and D output) with respect to marginal revenue.

α_x = $\dfrac{np^{1-\sigma}}{np^{1-\sigma}+n^*}$, share of spending on home country differentiated products.

γ = $\dfrac{\alpha E}{\alpha E + E_x^*}$, the home country's share of consumption of domestic differentiated products.

In order to simplify the calculations we substitute (17) into (15) in order to obtain:

$$(15') \qquad \alpha_x \hat{n} - \gamma S_n \hat{\pi} + [(1-\alpha_x)(\sigma-1) - \gamma S_x]\hat{p} + \hat{x} = \gamma[(1-\alpha_x)(\sigma-1) + m/E]dt +$$

$$+\{(1-\gamma)[\alpha_x + (1-\alpha_x)\sigma] - \gamma b/E\}de$$

Equations (13), (14), (15') and (16) enable us to calculate the effects of "small" doses of policy on resource allocation.

First, consider the effects of a small tariff. Direct calculation shows that:

$$(18a) \qquad \frac{1}{n}\frac{\partial n}{\partial(1+t)} = \frac{1}{\Delta}\gamma[(1-\alpha_x)(\sigma-1) + m/E](-\varepsilon_{20} + \varepsilon_{11}\varepsilon_{22} - \varepsilon_{12}\varepsilon_{21})$$

$$(18b) \qquad \frac{1}{\pi}\frac{\partial \pi}{\partial(1+t)} = \frac{1}{\Delta}\gamma[(1-\alpha_x)(\sigma-1) + m/E](1 + \varepsilon_{11} - \varepsilon_{21})$$

$$(18c) \qquad \frac{1}{p}\frac{\partial p}{\partial(1+t)} = \frac{1}{\Delta}\gamma[(1-\alpha_x)(\sigma-1) + m/E](1 + \varepsilon_{22} - \varepsilon_{12})$$

$$(18d) \qquad \frac{1}{x}\frac{\partial x}{\partial(1+t)} = \frac{1}{\Delta}\gamma[(1-\alpha_x)(\sigma-1) + m/E](\varepsilon_{20} - \varepsilon_{10})$$

where

$$(19) \qquad \Delta = [(1-\alpha_x)(\sigma-1)-\gamma S_x](1+\varepsilon_{22} - \varepsilon_{12}) + (1-\gamma S_n)(1+\varepsilon_{11} - \varepsilon_{21}) +$$

$$+ \alpha_x(-\varepsilon_{20} + \varepsilon_{11}\varepsilon_{22} - \varepsilon_{12}\varepsilon_{21})$$

and use has been made of the property $\varepsilon_{i0}+\varepsilon_{i1}+\varepsilon_{i2} = 0$, $i = 1,2$, where ε_{i0} is the elasticity of $R_i(\cdot)$ with respect to the price of the homogeneous product Y. The term Δ is assumed to be positive.

Properties of the demand system that affect the solution are represented by terms that are collected in the square brackets on the right hand side of (18), except for Δ, while the following parenthesis contain only supply elasticities. In order to limit the range of possible complementary and substitutionary relationships on the supply side we assume that all production activities; i.e., R and D, production of differentiated products and production of the homogeneous good, are substitutes in production. This implies:[1]

$$\varepsilon_{ii} \geq 0$$

$$\varepsilon_{ij} \leq 0, \; i \neq j$$

$$\varepsilon_{ii} + \varepsilon_{ij} \geq 0.$$

Given these assumptions about the structure of production (18) implies that a small tariff raises the price of differentiated products, it brings about higher operating profits, more R and D and domestic variety, and a larger aggregate output of differentiated products (the last result is obtained by combining (18a) with (18d) in order to calculate $\hat{n} + \hat{x}$.). However, output per firm may increase or decline, depending on whether the absolute value of the elasticity of supply of X with respect to the price of Y is larger or smaller than the absolute value of the elasticity of R and D with respect to the price of Y. If the production of X and Y uses many common resources in similar proportions, with the resources being highly substitutable for each other, and R and D requires highly specific resources which do not have good substitutes, then $|\varepsilon_{20}| < |\varepsilon_{10}|$ and a tariff brings about a higher utilization rate in the X-sector.

By increasing the price of foreign differentiated products the tariff shifts home demand from foreign to domestic differentiated products. This enables domestic producers to sell larger quantities at the initial price, making it profitable to raise prices and expand production. However, since the demand shift raises the profitability of home production, it thereby increases the return to product development, bringing about an expansion of R and D activity and more home produced varieties. The reason that these reallocations do not necessarily bring about an expansion of output by every single firm is that they generate two types of opposing pressures. On the one hand the demand shift towards a firm's product makes it willing to expand output. On the other hand the availability of additional varieties reduces the demand facing an individual firm, pressuring for an output contraction. The net outcome depends on the relative strenght of these pressures which are linked through the price response. The ability to charge a higher price makes it desirable to expand both output and R and D, and the desirability of expansion of each one of these activities depends on the relative ease with which it can be expand by employing resources that are being used in sector Y. The difference in elasticities $(\varepsilon_{20}-\varepsilon_{10})$ represents precisely this consideration.

A final point about tariffs concerns import protection as export promotion (see Krugman (1984)). Using (3'c) and (18) one finds that a tariff on differentiated products increases the value of exports of differentiated products in terms of the numeraire $(\hat{n}+\hat{p}+\hat{d}^* > 0)$. Hence, the tariff promotes exports. However, a calculation of the rate of change in the volume of exports $\hat{n}+\hat{d}^*$ shows that it most likely declines in response to the tariff; a sufficient condition for a decline in this volume is for the number of firms in the X-sector, and, therefore, also the available domestic variety, to be constant.

Next, consider the effects of a small export subsidy:

$$\text{(20a)} \qquad \frac{1}{n}\frac{\partial n}{\partial(1+e)} = \frac{1}{\Delta}\{(1-\gamma)[\alpha_x+(1-\alpha_x)\sigma] - \gamma b/E\}(-\varepsilon_{20} + \varepsilon_{11}\varepsilon_{22}-\varepsilon_{12}\varepsilon_{21})$$

$$(20b) \qquad \frac{1}{\pi}\,\frac{\partial\pi}{\partial(1+e)} = \frac{1}{\Delta}\{(1-\gamma)[\alpha_x+(1-\alpha_x)\sigma] - \gamma b/E\}(1+\varepsilon_{11} - \varepsilon_{21})$$

$$(20c) \qquad \frac{1}{p}\,\frac{\partial p}{\partial(1+e)} = \frac{1}{\Delta}\{(1-\gamma)[\alpha_x+(1-\alpha_x)\sigma] - \gamma b/E\}(1+\varepsilon_{22} - \varepsilon_{12})$$

$$(20d) \qquad \frac{1}{x}\,\frac{\partial x}{\partial(1+e)} = \frac{1}{\Delta}[(1-\gamma)[\alpha_x+(1-\alpha_x)\sigma] - \gamma b/E\}(\varepsilon_{20} - \varepsilon_{10})$$

Since $b/E = (1-\gamma)S_x$, we have:

$$(1-\gamma)[\alpha_x + (1-\alpha_x)\sigma] - \gamma b/E = (1-\gamma)[\alpha_x+(1-\alpha_x)\sigma-\gamma S_x] > 0$$

We find that by raising foreign demand for home varieties an export subsidy affects resource allocation in the same way as a tariff; there is more output of X, more R and D and larger operating profits. Domestic producers obtain a higher export price inclusive of the subsidy (p). Foreign buyers most likely pay a lower price (this can be seen from (20c) and (19) by calculating $\hat{p}$ - de) while domestic buyers pay a higher price. The scale of production of a single variety may increase or decline.

By comparing (18) with (20) it is seen that changes in (n,π,p,x) that result from an export subsidy differ from the corresponding changes that result from a tariff only by a factor of proportionality. Nevertheless, as we will show in the next section they have very different welfare implications.

The effects of a small production subsidy are given by

$$(21a) \qquad \frac{1}{n}\,\frac{\partial n}{\partial(1+z)} = \frac{1}{\Delta}[\alpha_x+(1-\alpha_x)\sigma -\gamma S_x](-\varepsilon_{20}+ \varepsilon_{11}\varepsilon_{22}-\varepsilon_{12}\varepsilon_{21})$$

$$\text{(21b)} \qquad \frac{1}{\pi}\frac{\partial\pi}{\partial(1+z)} = \frac{1}{\Delta}[\alpha_x+(1-\alpha_x)\sigma - \gamma S_x](1 + \varepsilon_{11} - \varepsilon_{21})$$

$$\text{(21c)} \qquad \frac{1}{p}\frac{\partial p}{\partial(1+z)} = \frac{1}{\Delta}[(1+\varepsilon_{22} - \varepsilon_{12}) + (1-\gamma S_n)(-1-\varepsilon_{11} + \varepsilon_{21}) +$$

$$+ \alpha_x(\varepsilon_{20} - \varepsilon_{11}\varepsilon_{22} + \varepsilon_{12}\varepsilon_{21})]$$

$$\text{(21d)} \qquad \frac{1}{x}\frac{\partial x}{\partial(1+z)} = \frac{1}{\Delta}[\alpha_x+(1-\alpha_x)\sigma - \gamma S_x](\varepsilon_{20} - \varepsilon_{10})$$

A production subsidy raises operating profits and brings about more product development. Aggregate output of differentiated products increases (combine (21a) with (21d) to calculate $\hat{n} + \hat{x}$) while output per firm may increase or decline. The price per unit output inclusive of the subsidy rises (combine (21c) with (19) to calculate $\hat{p} + dz$), but the consumer price may increase or decline.

In order to demonstrate two ends of possible outcomes consider the case in which the number of varieties is fixed (no resources are devoted to R and D, or resources used in R and D are not used in other activities) and the case in which the output level of Y is fixed (the production of X and R and D do not compete for resources with Y). In the former case:

$$\varepsilon_{20} = \varepsilon_{21} = \varepsilon_{22} = \varepsilon_{12} = 0$$

and the differentiated product industry expands by having every single firm expand its output level (see (21d)). Given this production structure (21c) implies:

$$\text{(21c')} \qquad \frac{1}{p}\frac{\partial p}{\partial(1+z)} = \frac{1}{\Delta}[1 - (1 - \frac{\alpha\alpha_x}{\sigma})(1 + \varepsilon_{11})]$$

where use has been made of the relationships $S_n = S_x/\sigma$ (from (10)) and $\alpha\alpha_x = \gamma S_x$. This shows clearly that the consumer price may increase or decline as a result of the production subsidy. The consumer price is sure to decline if the consumption elasticity of substitution between pairs of varieties σ, which is also equal to the demand elasticity, is sufficiently large or if the supply elasticity ε_{11} is sufficiently large. On the other hand, if ε_{11} is close enough to zero and σ is close enough to one consumers will not benefit from lower prices as a result of the output subsidy.

These results can be explained as follows. Using (17) and (21b-c) it can be shown that for the case under discussion domestic expenditure E declines in response to the production subsidy if and only if:

$$(1 - \frac{1}{\sigma})(1 + \varepsilon_{11}) > \frac{1}{\alpha_x}$$

Clearly, when domestic expenditure declines the firm's optimal response is to reduce output. But due to the subsidy it wishes to expand output. Therefore it reduces the consumer price in order to stimulate sales as long as the subsidy inclusive price is high enough. Indeed, the necessary and sufficient condition for an expenditure decline ensures

$$1 - (1 - \frac{\alpha\alpha_x}{\sigma})(1 + \varepsilon_{11}) < 0$$

which implies a decline in p (see (21c')). If, on the other hand, expenditure rises to a sufficiently high level, it proves profitable to raise the consumer price despite the output subsidy.

The last consideration comes out most clearly in the second example, in which the output level of Y is fixed. In this case:

$$\varepsilon_{10} = \varepsilon_{20} = \varepsilon_{11} + \varepsilon_{12} = \varepsilon_{21} + \varepsilon_{22} = 0$$

and

$$\frac{1}{p}\,\frac{\partial p}{\partial(1+z)} = \frac{1}{\Delta}\,\gamma S_n(1 + \varepsilon_{11} + \varepsilon_{22}) > 0$$

i.e., the price rises. This stems from the fact that under these circumstances production of X and R and D compete for the same resources, with both obtaining the same stimulus through the subsidy (operating profits and the subsidy inclusive price rise by the same proportion -- compare (21b) with $\hat{p} + dz$ obtained from (21c) and (19)). The result is that resources do not move; there is no change in the number of firms or in their output levels. However, since expenditure E has increased, the demand for home varieties has risen. Hence, the quantity demanded is brought in line with the constant output level through a higher consumer price.

Finally, consider the effects of a small R and D subsidy:

$$\text{(22a)} \qquad -\frac{1}{n}\,\frac{\partial n}{\partial(1-s)} = \frac{1}{\Delta}\,\{[\alpha_x + (1-\alpha_x)\sigma - \gamma(S_x + S_n)]\varepsilon_{22} + +(1-\gamma S_n)(\varepsilon_{11}\varepsilon_{22} - \varepsilon_{12}\varepsilon_{21})\}$$

$$\text{(22b)} \qquad -\frac{1}{\pi}\,\frac{\partial \pi}{\partial(1-s)} = \frac{1}{\Delta}\,\{[(1-\alpha_x)(\sigma-1) - \gamma S_x](-\varepsilon_{22} + \varepsilon_{12}) + +\alpha_x(-\varepsilon_{22} - \varepsilon_{11}\varepsilon_{22} + \varepsilon_{12}\varepsilon_{21})\}$$

$$\text{(22c)} \qquad -\frac{1}{p}\,\frac{\partial p}{\partial(1-s)} = \frac{1}{\Delta}[(1-\gamma S_n - \alpha_x)\varepsilon_{22} - (1-\gamma S_n)\varepsilon_{12}]$$

(22d) $$-\frac{1}{x}\frac{\partial x}{\partial(1-s)} = \frac{1}{\Delta}\{[\alpha_x + (1-\alpha_x)\sigma - \gamma(S_x + S_n)](-\varepsilon_{22}+\varepsilon_{12}) + \alpha_x(-\varepsilon_{22}\varepsilon_{11} + \varepsilon_{12}\varepsilon_{21})\}$$

Although the R and D subsidy tends to reduce operating profits (a sufficient condition for a decline in π is $\sigma > 1 + \alpha\alpha_x/(1 - \alpha_x)$), profits inclusive of the subsidy $\pi/(1-s)$ increase (a direct calculation shows that $\hat{\pi} + ds > 0$). This brings about an expansion of R and D, and with the development of more varieties more firms enter the differentiated product industry. The new entry brings about a contraction of the output level of every firm, but aggregate output increases (from (22a) and (22d) we find $\hat{n} + \hat{x} > 0$). The price of differentiated products may increase or decline. It is seen from (22c) that the price rises if (a) R and D output responds to its reward; and (b) $(1-\alpha_x) > \alpha\alpha_x/\sigma$ (since $\alpha\alpha_x = \gamma S_x = \gamma S_n\sigma$). If, on the other hand, $(1-\alpha_x) < \alpha\alpha_x/\sigma$ and the output level X is fixed (it uses no resources in common with Y and R and D, implying $\varepsilon_{12} = 0$), then the price of differentiated products declines in response to the R and D subsidy, because entry brings about fiercer competition with no ability of the industry to respond by means of an output expansion.

Our results on the response of the economy to various policies indicate that one needs detailed information about the economy's structure in order to predict them. This point is particularly forceful in view of the fact that we have used a very simple model. Naturally, in more complex environments that better approximate reality more details will be needed in order to make reliable predictions. Thus, we have seen that the degree of capacity utilization of a typical firm in a differentiated product industry may increase or decline in response to policies that are designed to help the domestic industry, such as import protection, export promotion or output promotion, with the response depending on the sectoral interactions through factor markets. And we have seen that the domestic consumer price of domestically produced varieties may increase or decline in response to policies that are designed to help the domestic industry, such as output and R and D subsidies. Here too the results depend on the sectoral interactions through factor markets and also on the details of consumer preferences. However, the required details can be identified and their role can be clarified by means of an analysis of the type reported in this section.

4. Welfare

We have shown in the previous section how a small tariff, a small export subsidy, a small output subsidy and a small R and D subsidy affect resource allocation. The question that is examined in this section is whether these policies are beneficial or harmful as measured by the overall utility level. For this purpose we combine the equilibrium relationship $d_Y = (1-\alpha)E$ with (1), (2) and (3') in order to obtain an indirect utility function:

$$\text{(23)} \qquad \log U = \text{constant} + \log E - \frac{\alpha}{1-\sigma} \log[np^{1-\sigma} + n^*(1+t)^{1-\sigma}]$$

As is common for this type of preferences the contribution of the X-products to aggregate welfare; i.e. u_X, can be represented by the spending level on these products deflated by a price index of the available varieties. The last term on the right-hand-side of (23) equals minus α (the share of differentiated products in aggregate spending) times the logarithm of this price index. It is clear from this expression that higher consumer prices of differentiated products, domestically produced or imported, imply a higher price index, thereby reducing the real value of spending on differentiated products and welfare. On the other hand, a larger variety choice of domestic or imported products reduces the price index, implying a higher real value of spending on differentiated products and a higher welfare level. It is therefore clear from (23) that the total welfare effect of a policy depends on its combined effect on this price index and on aggregate spending.

Total differentiation of (23), making use of (17) and the fact that $S_x = \sigma S_n$, $S_x - \alpha\alpha_x = b/E$ and $\alpha(1-\alpha_x) = m/E$, implies the following formula for the welfare effect of industrial policies at the initially no intervention point:

$$(24) \qquad \hat{U} = \frac{b}{E}(\hat{p}-de) + S_n\hat{\pi} + \frac{\alpha\alpha_x}{\sigma-1}\hat{n}$$

Thus, a policy that raises the home price of domestically produced varieties net of the export subsidy has a positive terms of trade effect and a positive welfare effect which is proportional to the share of these exports in aggregate income (= spending). Similarly, a policy that raises operating profits of firms in the differentiated product industry raises welfare because it raises income. This effect is proportional to the share of these profits in aggregate income. Finally, a policy that increases the number of varieties produced by domestic firms increases the variety choice available to consumers and thereby raises welfare. The degree of this welfare gain is proportional to the share of aggregate spending allocated to domestic varieties (= $\alpha\alpha_x$) and it is larger the less substitution there is in consumption across varieties.

It should be noted that for the four policy instruments considered in this study only the export subsidy has a direct welfare effect (as opposed to the indirect effects that result from changes in prices, profits and available varieties). The reason for this is as follows. Production and R and D subsidies raise directly factor rewards by increasing GDP (through their effect on $R(\cdot)$ -- see (6)) and they reduce disposable income through the tax rebate T. These two income effects are of equal size at the initial point of no policy intervention. A tariff does not affect GDP directly. However, a tariff reduces the real value of spending by raising the price index of differentiated products (see (23)). This real income effect is precisely offset by the tax rebate at the initial point of no policy intervention. Finally, an export subsidy has no direct effect on GDP or on the price index of differentiated products. Its only direct effect appears through the tax rebate, and this is precisely what appears in (24). The negative income effect of the subsidy is proportional to the share of exports in aggregate income and spending.

Using the results from the previous section it is now straightforward to see that a small tariff is beneficial. Its direct effect is nil, as we explained above. In addition, it generates a positive terms of trade effect, it raises income by raising operating profits, and it enlarges the variety choice available to domestic consumers. For the case of a constant number of firms the increase in operating profits represents the rent gain that has been emphasized by Brander and Spencer (1984). However, since our model is richer than theirs, we obtain additional effects and interactions.

We have shown in the previous section that an export subsidy and a tariff generate proportional changes in (n, π, p, x). Despite this similarity an export subsidy need not have the same welfare effect as a tariff because by raising the domestic price p of differentiated products the tariff improves the terms of trade while an export subsidy may deteriorate them, since the proportional change in the price paid by foreigners is $(\hat{p} - de)$ and from (20c) and (19) this is most likely negative. Thus, an export subsidy may have a negative welfare effect through its deterioration of the terms of trade and a positive welfare effect through the increase in operating profits and the variety choice.

In order to see that an export subsidy can indeed be harmful consider the case in which the number of varieties is fixed, which implies:

$$\varepsilon_{20} = \varepsilon_{21} = \varepsilon_{22} = \varepsilon_{12} = 0$$

In this case (19), (20b), (20c) and (24) imply:

$$\hat{U} = -\frac{S_n}{\Delta}(1-\gamma)\{\gamma\sigma[\alpha_x+(1-\alpha_x)\sigma-\gamma S_x] +\alpha_x(\sigma-1)(1+\varepsilon_{11}) + \sigma\} < 0$$

(In this calculation use has been made of the relationships $S_x = \sigma S_n$ and $b/E = (1-\gamma)S_x$.) Hence, lack of flexibility in the supply of R and D makes an export subsidy harmful. Clearly, in this case an export tax is welfare improving, because it improves the terms of trade to a degree which overcomes its negative effect on operating profits.

This result should be contrasted with the recent line of argument by Brander and Spencer (1985) that in the presence of oligopolistic interactions an export subsidy is a beneficial strategic instrument. In their model, which does not take account of intersectoral interactions, the negative terms of trade effect is outweighted by the positive profits effect, just the opposite of our result for the case of a fixed number of firms. As argued by Eaton and Grossman (1983) the benefit of an export subsidy as a strategic instrument for oligopolistic industries rests heavily on the assumption that firms play a Cournot (quantity) game. If they play a Bertrand (price) game, the result is reversed -- exports should be taxed. Hence for the case of a fixed number of firms our result, which has been derived for a differentiated product industry with monopolistic competition, is in line with the Eaton-Grossman result for Bertrand-type oligopolies. It should, however, be borne in mind that in our case desirability of an export subsidy depends on entry opportunities (see also Horstman and Markusen (1984) on this point) and the nature of the entry activity's (product development) competition for resources with the other activities; i.e., whether it uses resources that are mainly used in the production of X or Y, whether its factor composition is similar to the factor composition used in X or Y, etc.

An output subsidy raises welfare in certain circumstances and reduces welfare in other. For example, if the output level of the homogeneous product is constant so that production of differentiated products competes for resources with R and D, then -- as we have shown in the previous section -- an output subsidy improves the terms of trade. Since under these circumstances the domestically produced number of varieties does not change while profitability increases (see (21a-b), there is a welfare gain from the subsidy (see (24)). If, on the other hand, production of differentiated products competes for resources with homogeneous products while the number of varieties is fixed, then for sufficiently large values of σ and ε_{11} an output subsidy deteriorates the terms of trade (see (21c')). Moreover, using (21) and (24) it can be shown that under these circumstances (i.e., $\varepsilon_{20} = \varepsilon_{21} = \varepsilon_{22} = \varepsilon_{12} = 0$) welfare declines if and only if:

$$(1-\gamma) + (1+\varepsilon_{11})[\gamma(1 - \frac{\alpha\alpha_x}{\sigma}) - \alpha_x(1 - \frac{1}{\sigma})] < 0$$

Hence, if $\alpha_x > \gamma$ and σ and ε_{11} are sufficiently large the output subsidy is harmful in welfare terms while a tax on the production of differentiated products is welfare improving. It is clear from this discussion that important details about the economy have to be known in order to design a desirable policy towards the industry's output level.

As far as R and D subsidies are concerned we have shown that a small subsidy increases variety, but it may reduce or increase operating profits exclusive of the subsidy and the price of differentiated products. A larger variety choice is welfare promoting, but lower operating profits and prices (the latter due to its negative terms of trade effect) are welfare reducing. The beneficial variety effect is proportional to the share of spending on domestic differentiated products in total spending on differentiated products, α_x, as can be seen from (24). In a very small country, in the case where the ratios of domestic to foreign varieties and domestic to foreign spending approach zero, and, hence, $\alpha_x \to 0$ and consequently $\gamma \to 0$, the effect of increased variety of an R and D subsidy disappears, but the remaining total effect of price and profits on welfare is nevertheless positive:

$$\hat{U} = \frac{1}{\Delta} \frac{Sx}{\sigma}(\varepsilon_{22} - \varepsilon_{12}) > 0.$$

This combined effect is composed of a negative effect on profits and a positive terms of trade effect (see (22b) and (22c) respectively, and note that $\gamma \to 0$ as $\alpha_x \to 0$). Thus a small subsidy to R and D improves welfare in the very small country. It is, however, not certain that welfare will improve in general. For example, if we let the proportion of total spending on differentiated products be negligible; i.e., $\alpha \to 0$, the total welfare effect

$$\hat{U} = \frac{1}{\Delta} S_x \{ \frac{1}{\sigma} (1-\alpha_x)(\varepsilon_{22} - \varepsilon_{12}) - \alpha_x [\frac{\varepsilon_{11}\varepsilon_{22} - \varepsilon_{12}\varepsilon_{21}}{\sigma} + \varepsilon_{12}(1 + \frac{1}{\sigma})] \}$$

(using (24) and (22) and the fact that $\gamma \to 0$ as $\alpha \to 0$) is negative for appropriate values on the parameters. One such set of parameter values is: $\sigma \to 1$ (i.e., very low substitutability of varieties in consumption), $\alpha_x = 0.1$, $\varepsilon_{22} = \varepsilon_{11} = 10$, $\varepsilon_{12} = \varepsilon_{21} \to 0$ (i.e., the production of differentiated products and R and D compete for resources with the homogeneous product sector, but hardly with each other), which gives $\hat{U} = - S_x/\Delta$. In this case, the positive variety effect is also eliminated, because virtually nothing is spent on differentiated products, but in contrast to the very small country case, the negative effect on welfare through decreased operating profits may outweigh the positive terms of trade effect. This shows clearly that the Spencer and Brander (1983) result on the beneficial effect of an R and D subsidy depends crucially on the absence of certain types of intersectoral dependencies; our example demonstrates that there exist types of intersectoral interactions in factor markets that make an R and D subsidy harmful. It should, however, be added that when spending on differentiated products is non-negligible, we have not been able to find a case where an R and D subsidy results in decreased welfare.

5. Summary and conclusions

Our analysis of commonly used instruments of industrial policy has revealed that their effectivness is sensitive to the economy's structure. By shifting demand towards domestic products a tariff on their imports of differentiated products raises the profitability of domestic production, thereby bringing about a larger domestically produced variety (through new entry into the industry) and higher prices charged by domestic firms. This may increase or reduce the rate of capacity utilization, depending on whether product development competes for resources mainly with the production of differentiated products or with homogeneous products, as well as on other details of the production structure, but it necessarily raises income and improves the terms of trade. Consequently, aggregate welfare rises. It should, however, be noted that this welfare effect depends to a large extent on one important feature of our model; namely, the absence of other noncompetitive industries that produce with economies of scale. The presence of such industries may reduce or eliminate the welfare enhancing property of the tariff.

An export subsidy to differentiated products has similar allocative effects. By stimulating foreign sales the export subsidy increases the profitability of domestic production, thereby attracting new firms into the industry and bidding up the domestic price. Aggregate output of differentiated products increases, as in the tariff case, and the rate of capacity utilization may increase or decline. Larger domestic variety and higher profits increase domestic real income, again as in the tariff case. However, in contrast to the tariff case the higher domestic price of differentiated products does not ensure an improvment in the terms of trade, because it is possible for the domestic price to increase proportionally less than the export subsidy. In the latter case the subsidy deteriorates the economy's terms of trade. We have shown that there exist circumstances in which the negative terms of trade effect dominates the positive real income effect, in which case the overall welfare effect of the export subsidy is negative.

An output subsidy to differentiated products also increases the profitability of domestic production of differentiated products, induces new entry into the industry, and brings about an expansion of aggregate output. However, unlike a tariff or an export subsidy, it does not lead to a necessarily higher domestic price of differentiated products. Consequently, the positive welfare effect that is generated by more variety and larger profits can be outweighed by a negative terms of trade effect, bringing about an overall loss as a result of this policy. An output subsidy is welfare improving if it improves the terms of trade or if it induces a relatively small deterioration in the terms of trade. Which case applies depends on various details of production and consumption characteristics and the nature of sectoral interactions in factor markets.

An R and D subsidy always increases profits inclusive of subsidy in the differentiated products industry (but tends to reduce profits exclusive of subsidy). This induces an expansion of R and D, i.e., more varieties appear, and more firms enter the industry. The increased number of firms results in higher aggregate output, but lower output per firm. The price of differentiated products may increase or decline; the firms will lower their prices in the face of increased competition if the scope for aggregate output expansion is limited. An R and D subsidy normally improves welfare in our model. Even if the unambiguously positive effect on welfare of increased variety is negligible, as it is in the very small country, the negative effect of lower operating profits is outweighed by improved terms of trade. Only in the case of negligible total spending on differentiated products have we been able to show a detrimental effect on welfare of R and D subsidies.

One conclusion that emerges from our study is that a more general economic structure, which includes intersectoral interactions and entry and exit opportunities in the differentiated products industry, weakens the case for policy intervention. It can be presumed that an even more general structure, with more than one noncompetitive sector, would cast further doubt on the prospect of beneficial industrial policy.

A second conclusion is that although there potentially exists a case for industrial policy, its nature is as yet unknown; every policy has to be evaluated for each country separately, using detailed information about the structure of its industries, their interaction through factor markets, the nature of competition that prevails in the various industries and the structure of preferences. To collect the necessary information and then to evaluate contemplated policies seems a formidable, if not impossible task. Moreover, in any practial application one would have to take into account similar policies by trading partners, as well as retaliation, which has not been done in this study, nor in the other studies cited in this paper.

FOOTNOTES

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1. Our assumptions on substitutability in production imply that $\varepsilon_{10} > \varepsilon_{20}$ is a sufficient condition for $\Delta > 0$; i.e., if the general equilibrium supply elasticity of X with respect to the price of Y is larger in absolute value than the corresponding elasticity of product development with respect to the price of Y. This will be the case if, for example, the production of X and Y uses highly substitutable common factors in similar proportions, while R and D require specific factors which do not have good substitutes. The proof of this is as follows. From (19):

$$\begin{aligned}
\Delta &> -\gamma S_x(1+\varepsilon_{22}-\varepsilon_{12}) + (1-\gamma S_n)(1+\varepsilon_{11}-\varepsilon_{21}) \\
&= \gamma S_x(\varepsilon_{11}-\varepsilon_{21}-\varepsilon_{22}+\varepsilon_{12})+(1-\gamma S_n-\gamma S_x)(1+\varepsilon_{11}-\varepsilon_{21}) \\
&> \gamma S_x(\varepsilon_{11}-\varepsilon_{21}-\varepsilon_{22}+\varepsilon_{12}) \\
&= \gamma S_x(\varepsilon_{20}-\varepsilon_{10}).
\end{aligned}$$

It is also clear from (19) that $(1-\alpha_x)(\sigma-1) > \gamma S_x$ is a sufficient condition for $\Delta > 0$. This is satisfied if the differentiated products are highly substitutable for each other and the country consumes a small share of output of its differentiated products.

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