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On the equivalence of quantitative trade restrictions and tariffs ☆

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Abstract

A difficulty with industrial policy regarding the uncertainty about infant industries' long-term potential. We argue that alternative commercial policy instruments may be associated with differences in the speed and accuracy with which the government learns about industry type.

Keywords: Industrial policy; Trade instruments; Learning; Bayes procedure; Infant industry

JEL classification: E32; E52

1. Introduction

In a static, deterministic, perfectly competitive environment, Baghwati (1965) established that tariffs and quotas are equivalent, in the sense that they can support the same quantity and price of imports in equilibrium and also lead to the same level of welfare. A large literature has subsequently shown that this result does not easily generalize to different environments. For instance, the equivalence breaks down in the presence of uncertainty, when the factors of production are internationally mobile, when the foreign economy can retaliate against the domestic trade policies, when technological choice is endogenous, and in various situations involving imperfect competition and asymmetric information. Nonequivalence is

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important because, in this case, the two instruments can be ranked in terms of their ability to satisfy any given commercial policy objective.

The objective of this paper is to extend the concept of equivalence by introducing a distinction between the short and the long run. We will argue that there exist interesting cases in the real world where tariffs and quotas have equal protective power, in the sense that they have identical implications for the *average* quantity of imports in the short-medium run. But in the long run, the two instruments can be ranked in spite of the fact that firms are risk neutral, that there are no strategic interactions between firms or asymmetric information—or any of the other conditions which have been identified in the literature as giving rise to nonequivalence. Our approach is related to and represents an extension of Weitzman (1974) who asked the general question of whether prices or quantities are a superior regulatory device under conditions of *inadequate* information or uncertainty. We apply this to the well known case of industrial policy and infant industries, where the type of the industry (high or low potential) is not known in advance and must be inferred by the policymakers through observations on current and past industry performance.

We establish that alternative commercial policy instruments are associated with differences in the informational content of such observations. The information content depends on the degree of volatility in domestic output, which in turn depends on the sources of shocks, the policy in place, as well as the characteristics of demand and costs. In a model of infant industry with learning-by doing effects, we derive the conditions under which a tariff is superior to a quota in the sense that it allows policymakers to learn faster and/or more accurately the true type of the industry they are protecting.

2. The model

We illustrate our argument in the context of a model of optimal infant industry protection due to Melitz (2005).

2.1. Technology

There are two non-storable goods which are produced competitively, one at home and the other abroad. Production exhibits constant returns to scale. The domestic industry can be one of two types, "mature" or "infant". The mature type incurs marginal cost c_t in period t, given by

$$c_t = \overline{c} + \varepsilon_t,$$

where $\overline{c}>0$, and $\varepsilon_t \sim \mathrm{IID}(0, \sigma_c^2)$. c_t is publicly observable but $\overline{c}>0$, and ε_t is not.

The infant type has marginal costs that decrease over time due to learning-by-doing effects as a function of cumulative past production:

$$c_t = \max\{\overline{\overline{c}} - v_H Q^{(t-1)}, \underline{c}\} + \varepsilon_t, \quad v_{\mathrm{H}}>0. \tag{1}$$

$\overline{\overline{c}}$ may be different from $\overline{c}$. Again c_t is assumed to be publicly observable while its individual components are not. This is the source of the industry identification problem for the policymakers. Without loss of generality we assume that the noise in marginal costs is the same for both industry types.

Let q_t and $Q^{(t-1)}$ denote period ts domestic output and past cumulative output. They are related by the recursion

$$Q^{(t-1)} = \sum_{j=1}^{t-1} q_j = q_{t-1} + Q^{(t-2)} \quad \text{with } Q^{(0)} = 0 \text{ and } t = 2,3,\ldots \tag{2}$$

For an infant industry, the deterministic part of its marginal cost declines to a minimum of $\underline{c}$, and then stays constant at that level thereafter.

The foreign good is also produced with constant marginal cost, $\tilde{c}_t>0$, where $\tilde{c} \sim \mathrm{IID}(\tilde{c}, \tilde{\sigma}_c^2)$ with $\tilde{c}>0$.

2.2. Preferences

Domestic demand is generated by a representative consumer whose instantaneous utility function is additively separable in some numeraire good. In what follows, foreign variables – such as imports and prices – will be indicated by a "~" over the variable. The utility in period t from consuming $(q_t, \tilde{q}_t)$ is given by a strictly concave utility function U. Following Melitz (2005), we analyze the case of quadratic utility and allow for substitutability between the domestic and foreign good. In particular, the utility function takes the following form:

$$U(q_t, \tilde{q}_t) = -\frac{\beta}{2}(a_t - q_t)^2 - \frac{\beta}{2}(b - \tilde{q}_t)^2 - \beta\eta q_t \tilde{q}_t, \quad \beta>0, \eta\in[0,1].$$

Given prices p_t and $\tilde{p}_t$, the representative consumer maximizes consumer surplus $U(q_t, \tilde{q}_t) - p_t q_t - \tilde{p}_t \tilde{q}_t$. This yields the following linear demand curves in period t:

$$q_t = \frac{a_t - \eta_b}{1-\eta^2} + \frac{\eta}{\beta(1-\eta^2)}\tilde{p}_t - \frac{1}{\beta(1-\eta^2)}p_t \tag{3}$$

$$\tilde{q}_t = \frac{b - \eta a_t}{1-\eta^2} + \frac{\eta}{\beta(1-\eta^2)}p_t - \frac{1}{\beta(1-\eta^2)}\tilde{p}_t \tag{4}$$

where a_t is a preference shock with the property at $a_t \sim \mathrm{IID}(0, \sigma_a^2)$. The parameter $\beta>0$ indexes the response of quantity demanded to the price of the corresponding good whereas $\eta\in[0, 1]$ captures the substitutability (or inverse level of product differentiation). Product substitutability increases as η goes from 0 (unrelated goods) to unity (perfect substitutes).

Depending on the trade regime, domestic sales may be exposed to three sources of variance: domestic demand shocks a_t and shocks to marginal costs of domestic production, c_t, and foreign production, $\tilde{c}_t$.

2.3. Equilibrium

In each period, the values of a_t, $\tilde{c}_t$ and c_t are realized independently of each other and are publicly observed. Under free trade and the assumption of competitive production of both goods, the equilibrium values of $(q_t, \tilde{q}_t)$ will be given by Eqs. (3) and (4) after replacing p_t and $\tilde{p}_t$ by the marginal costs of production, c_t and $\tilde{c}_t$, respectively.

3. Trade regimes

We are now in a position to analyze the stochastic properties of q_t under different trade regimes. In particular, we consider three cases: a tariff, a quota, and a subsidy.

3.1. Tariff

Under a tariff τ, the foreign price $\tilde{p}_t$ becomes:

$$\tilde{p}_t = \tilde{c}_t + \tau.$$

For a given value of $Q^{(t-1)}$, the variance of q_t is given by:

$$\mathbb{V}\left(q_t;Q^{(t-1)}\right)|_{\text{tariff}} = \frac{1}{(1-\eta^2)^2}\sigma_a^2 + \frac{\eta^2}{\beta^2(1-\eta^2)^2}\tilde{\sigma}_c^2 + \frac{1}{\beta^2(1-\eta^2)^2}\sigma_c^2. \tag{5}$$

3.2. Quota

Under a quota, the quantity of the foreign good is held fixed at some level $\tilde{q}^*$. Given this quantity, the price of the foreign good $\tilde{p}$ adjusts according to the demand Eq. (4). According to Eq. (4), the equilibrium price in the imports market as a function of $\tilde{q}^*$ is:

$$\tilde{p}_t = \beta(b-\eta a_t) + \eta p_t - \beta(1-\eta^2)\tilde{q}^*.$$

Inserting this expression for $\tilde{p}$ in the domestic demand Eq. (3), we get:

$$q_t = a_t - p_t - \eta\tilde{q}^*.$$

For a given value of $Q^{(t-1)}$, the variance of domestic quantity then becomes:

$$\mathbb{V}(q_t;Q^{(t-1)})|_{\text{quota}} = \sigma_a^2 + \sigma_c^2. \tag{6}$$

We see that shocks to the foreign price (through the marginal cost $\tilde{c}_t$) do not affect domestic quantities. Comparing expressions (5) and (6), we have:

$$\boxed{\mathbb{V}\left(q_t;Q^{(t-1)}\right)|_{\text{tariff}} > \mathbb{V}\left(q_t;Q^{(t-1)}\right)|_{\text{quota}} \qquad \text{if } \beta(1-\eta^2) < 1.} \tag{7}$$

3.3. Subsidy

Under a subsidy s_t, the domestic price is

$$p_t = c_t - s_t.$$

It is straightforward to verify that, given $Q^{(t-1)}$, the variance of q_t is the same as that obtained under a tariff. Consequently, tariffs and subsidies are equivalent from the perspective of their effect on the variance of q_t and on its effect on learning.

3.4. Inference on the learning function parameter

Suppose that a regulator is trying to learn in period T the cost-type of the domestic goods producer. For the sake of the argument, we assume that learning is not yet completed, i.e. $Q^{(T)}<(\overline{\overline{c}}-\underline{c})/v_{\mathrm{H}}$. The regulator observes the prices and the transacted quantities $\{(q_1, p_1), (q_2, p_2),\ldots,(q_T, p_T)\}$ and must classify the industry into a mature industry (type 1) or into an infant industry (type 2). Knowing the learning schedule (1), he can run a regression of price on cumulative quantities:

$$p_t = c - vQ^{(t-1)} + \varepsilon_t \tag{8}$$

As is well known, the OLS estimate of v, $\hat{v}$, is

$$\hat{v} = -\frac{s_{pQ}}{s_Q^2} \quad \text{with } s_{pQ} = \sum_{t=1}^{T} (p_t - \overline{p})\left(Q^{(t-1)} - \overline{Q}\right) \text{ and } s_Q^2 = \sum_{t=1}^{T} \left(Q^{(t-1)} - \overline{Q}\right)^2$$

where $\overline{p}$ and $\overline{Q}$ are the arithmetic means of the observed prices and cumulated quantities. Under some regularity conditions, this estimator is consistent and, for large enough samples, approximately normally distributed:

$$\hat{v} \sim N(v_i, \sigma_{\hat{v}}^2), \qquad v_i \in \{0, v_{\mathrm{H}}\},$$

depending on the true value of v_i. The variance $\sigma_{\hat{v}}^2$ equals $\hat{\sigma}_c^2/s_Q^2$ under both alternatives where $\hat{\sigma}_c^2$ is the least squares estimator of σ_c^2.[1] The problem of the regulator is then reduced to deciding whether v is equal to zero (type 1 industry) or to v_H (type 2 industry). This then becomes a *standard classification problem* which can be treated by the method exposed in Anderson (1984, chapter 6).

Suppose that with probability π_1 the industry belongs to the mature high cost industry (type 1 industry) and with probability $\pi_2 = 1 - \pi_1$ it belongs to the infant industry (type 2 industry). The densities of $\hat{v}$ for the two cases are

$$f_i(\hat{v}) = \frac{1}{\sqrt{2\pi\sigma_{\hat{v}}^2}} \exp\left(-\frac{1}{2\sigma_{\hat{v}}^2}\left(\hat{v} - v_i\right)^2\right), \qquad v_i \in \{0, v_{\mathrm{H}}\}. \tag{9}$$

A classification rule is a partition of $\mathbb{R}$ into two regions R_1 and R_2 such that the industry is classified as being of type 1 if $\hat{v} \in R_1$ and of type 2 if $\hat{v} \in R_2$. Denoting the cost of misclassifying an industry as of type 2 if it really is of type 1 by $C(2|1)$ and the cost of misclassifying an industry as of type 1 if it really is of type 2 by $C(1|2)$ the expected cost of misclassification C is given by

$$C = C(2|1)\pi_1 \int_{R_2} f_0(x)\mathrm{d}x + C(1|2)\pi_2 \int_{R_1} f_{v_{\mathrm{H}}}(x)\mathrm{d}x \geq 0 \tag{10}$$

A regulator who follows a *Bayes procedure* chooses R_1 and R_2 in order to minimize Eq. (10). It can be easily shown that the expected cost of misclassification is a decreasing function of Δ, the Mahalanobis distance between the two distributions (Eq. (9)). In our case, Δ is given by

$$\Delta^2 = \frac{v_{\mathrm{H}}}{\sigma_{\hat{v}}^2} = \frac{v_H s_Q^2}{\hat{\sigma}_c^2}.$$

[1] If the regulator knows σ_c^2, he can replace the estimate by this number.

Therefore, the expected cost of misclassification is decreasing in s_Q^2. Because the learning schedule implies that output is positively autocorrelated, the variance of the cumulative output, $Q^{(t)}$, is increasing:

$$\mathbb{V}(Q^{(t)}) \geq \mathbb{V}(q_t) + \mathbb{V}(Q^{(t-1)})$$

Given the inequality (7), the variance of $Q^{(t)}$ is expected to be larger under a tariff than under a quota. Therefore the expected cost of misclassification will be lower under a tariff than under a quota because the greater variability of the quantities helps in the identification of the true type.

4. Conclusion

Industrial policy is quite widespread, in spite of the fact that there exist significant obstacles to its successful implementation. While moral hazard is often cited as the most important limitation to the successful conduct of industrial policy, imperfect knowledge of the true, long-term economic potential of the various sectors that vie for government support seems equally important. Empirical failures in identifying the "right" sector do not seem to deter governments from trying to pick winners, so it is worth asking whether this process could be improved by the judicial selection of the appropriate supporting commercial policy. In this paper we have argued that, in general, tariffs and quantitative trade restrictions may be ranked in terms of their ability to deliver a speedy and accurate assessment of the protected industry's true potential. We have used a standard infant industry learning-by-doing model to construct an example that demonstrates the conditions under which a tariff may be the superior instrument according to this criterion.

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