PERMANENT vs. TEMPORARY INFANT INDUSTRY ASSISTANCE

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ABSTRACT

This paper develops a two period model in which a dynamic external economy, in the form of learning-by-doing spillovers, provides the rationale for infant industry assistance. The incentive effects of permanent and temporary assistance are then examined by introducing owner/manager effort into the learning process. It is shown, under conditions of symmetric information, that temporary assistance is optimal. Under conditions of asymmetric information, it is shown that a form of permanent assistance is optimal if the policy maker can commit to a Period 1 per unit output subsidy and a Period 2 lump-sum subsidy contingent on Period 2 output.
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1. Introduction

There seems to be general agreement, at least in the academic literature, that some form of dynamic external economy must exist for there to be a rationale for infant industry assistance, [Kemp (1966), Baldwin (1969), Krueger and Tidser (1982), and Sutter (1987)]. It is usually argued that this assistance should be temporary because of a technological assumption that the dynamic external economy disappears once the industry matures. [Corden (1974), p 256].

The dynamic external economy most often considered is learning-by-doing within a firm which has spillover effects to other firms and industries. Learning-by-doing is usually modelled through a relationship whereby a firm's current marginal cost is lower the greater is its cumulative output prior to the current period [Spence (1981) and Gudeburg and Tirole (1983)]. This paper continues in this tradition but adds a new element. Specifically, learning-by-doing only occurs if the firm's owner/operator expends some effort in the learning process.\(^1\) It is assumed that owner/operator effort increases the probability that learning will occur, that is, a deterministic relationship between effort and learning does not exist.\(^2\) It is also assumed that the firm can only obtain learning-by-doing in the first period, this eliminates problems of time consistency which have been investigated in Matsuyama (1990).\(^3\) On the surface it might seem that this assumption is similar to the technological assumption made in the traditional infant industry literature which ensured only temporary assistance. However, given the externality, there may be a role for permanent assistance as this increases the long term profitability of the firm and increases the incentive for the firm.

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\(^1\) This idea was alluded to in Baldwin (1969), p. 299.

\(^2\) Wright (1990) models learning-by-doing in this way, but does not consider the question of permanent versus temporary infant industry assistance.

\(^3\) Although not modelled, if the world price falls over time because of learning-by-doing abroad and the domestic firm does not obtain learning-by-doing in the first period, then its future losses can be so large that it is optimal for the policy maker to give no assistance in the second period and essentially close the industry down. Rather than modelling foreign learning-by-doing, to simplify the analysis without losing any insight, it is assumed that the domestic firm can only obtain learning in the first period.
to obtain the socially optimal amount of learning. This might be especially so where the
effort of the owner/manager is unobservable to the policy maker.

For a two period model, demand and cost conditions are outlined in Section 2. In
Section 3, it is assumed that there is symmetric information in that the policy maker can
observe owner/manager effort. As a result, the policy maker can directly subsidize this
effort. It is shown that temporary assistance, in the form of Period 1 per unit output and
effort subsidies, is optimal.

In Section 4, it is assumed that there is asymmetric information in that the policy maker
can not observe the effort of the owner/manager. Where the policy maker is restricted to per
unit output subsidies, once again it is shown that temporary assistance is optimal. This is
despite the fact that Period 2 per unit output subsidies encourage the firm to obtain learning.
Where the policy maker can commit to a Period 2 lump-sum payment contingent on Period
2 output as well as a Period 1 per unit output subsidy, it is shown that this particular form
of permanent assistance is optimal. In fact, this form of permanent assistance duplicates
the symmetric information solution. Section 5 provides some concluding remarks.

2. Demand and Cost Conditions

The domestic economy is assumed to be a small open economy. Therefore, domestic
firms are price takers at the world price, \( p^w \).

It is assumed that production takes place in two periods. Period 1 is the learning phase
and it is assumed that learning can only occur in this period. Period 2 is the mature phase
where learning has ceased. In Period 1, a single domestic firm's cost function is given by
\( c_1(q_1) \), where \( q_1 \) is Period 1 output, \( c_1'(q_1) > 0 \), and \( c_1''(q_1) > 0 \). That is, marginal cost is
increasing with output.\(^4\)

As a result of learning-by-doing, in Period 2, a single firm's cost function is given by
\[
c_2(q_2) = c_1(q_1) - \theta \cdot f(q_1) \cdot q_2. \quad (2.1)
\]

\(^4\) It is best to think of this increasing marginal cost arising from increases in factor prices as the industry expands rather than arising from diseconomies of scale.

where \( q_2 \) is Period 2 output, \( f(q_1) \) encapsulates the traditional formulation of the learning
curve with \( f'(q_1) > 0 \) and \( f''(q_1) < 0 \), and
\[
\theta = \begin{cases} 1, & \text{with probability } \rho(a); \\ 0, & \text{with probability } (1 - \rho(a)). \end{cases} \quad (2.2)
\]

where \( a \) measures the effort expended by the firm's owner/manager to obtain learning, and
\( \rho'(a) > 0, \rho''(a) < 0, \rho(a) = 0 \text{ if } a = 0, \text{ and } \rho(a) < 1 \forall a \). The conditions on \( \rho(a) \) capture
the idea that the higher is effort expended by the owner/manager in the learning process,
the higher is the probability that learning will occur. If \( \theta = 1 \), then Period 2 marginal cost is
\[
c_2(q_2) = c_1(q_1) - f(q_1). \quad (2.3)
\]

It is assumed that learning spills over from the industry being considered to other
industries in the domestic economy and this externality provides the rationale for infant
industry protection.\(^5\) In the presence of learning-by-doing and the learning spillover, it is
assumed that only one firm produces the product of interest in the domestic economy.\(^6\)

3. Symmetric Information

The presence of the learning spillover means that in the absence of government policy
welfare will not be maximized. As a result, both output and effort subsidies can be used
to increase welfare. In this section, it is assumed that the policy maker can observe
owner/manager effort and so can directly subsidize effort.

3.1 The Firm's Problem

In Period One, given \( q_1 \) and \( w_1 \), where \( q_1 \) is the Period 1 output subsidy and \( w_1 \) is
the Period 1 effort subsidy, the firm maximizes expected profit by choosing \( a \) and \( q_1 \). In

\(^5\) Source (1987) argues that inter-industry learning spillovers are an important source of industry
spillovers, especially for developing countries.

\(^6\) This assumption is the dynamic analogue of assuming natural monopoly in the presence of static
externalities of scale which are large relative to the size of the market. It maximizes the opportunity of
obtaining the learning.
Period Two, given $s_2$, where $s_2$ is the Period 2 output subsidy, and given the resolution of uncertainty and so the Period Two cost function, the firm chooses $q_2$ to maximise profit.

As is usual, this problem is solved backwards to guarantee optimal decisions are made at the start of each period.

3.1.1. Period Two

In Period 2, given the resolution of uncertainty and $s_2$, the firm maximises profit by choosing $q_2$. The firm's problem is

Problem 1:

$$\max_{q_2} \{ \Pi_2(q_2) = p^* - c(q_2) - \theta \cdot f(q_2) + s_2 \cdot q_2 \}. \quad (3.1)$$

Assuming an interior solution, the first order condition for a maximum is

$$p^* - c(q_2) + \theta \cdot f(q_2) + s_2 = 0. \quad (3.2)$$

Let the solution to this condition be given by $\bar{q}_2(q_1, \theta, p^*, s_2)$ and let maximised profit be given by $\bar{\Pi}_2(q_1, \theta, p^*, s_2)$.\footnote{The second order condition for a maximum is satisfied because of the convexity of the cost function.} Applying the implicit function theorem yields the following comparative static results

$$\frac{\partial \bar{q}_2}{\partial q_1} = \frac{\theta \cdot f'(q_1)}{c'(q_2)} > 0 \quad (3.3)$$

and

$$\frac{\partial \bar{q}_2}{\partial s_2} = \frac{1}{c'(q_2)} > 0. \quad (3.4)$$

3.1.2. Period One

In Period 1, given $s_1$ and $w_1$, the firm maximises expected profit by choosing $a$ and $q_1$.

The firm's problem is

$$\max_{a, q_1} \{ \Pi_1(a, q_1, p^*, s_1, s_2, w_1) = p^* \cdot q_1 - c(q_1) + s_1 \cdot q_1 + \rho(a) \cdot \bar{\Pi}_2(a, q_1, p^*, s_1, s_2, w_1) \} \quad (3.5)$$

where $\bar{\Pi}_2(a, q_1, p^*, s_1, s_2, w_1)$ denote maximised Period 2 profit where $\theta = 1$ and $\theta = 0$ respectively and $\rho(a)$ is the cost of owner/manager effort with $\nu(a) > 0$ and $\nu'(a) > 0$. Assuming an interior solution, after applying the envelope theorem and noting that $\frac{\partial \bar{\Pi}_2(a, q_1, p^*, s_1, s_2, w_1)}{\partial a} = 0$, the first order conditions for a maximum are

$$\frac{\partial \Pi_1(a)}{\partial a} = \rho'(a) \cdot (\bar{\Pi}_2(1) - \bar{\Pi}_2(0)) - \nu'(a) + w_1 = 0 \quad (3.6)$$

and

$$\frac{\partial \Pi_1(q_1)}{\partial q_1} = p^* - c'(q_1) + s_1 + \rho(a) \cdot f'(q_1) \cdot \bar{q}_2(1) = 0. \quad (3.7)$$

It is assumed that the second order conditions for a maximum are satisfied.

Let the solution to the first order conditions be given by $\bar{q}_1(p^*, s_1, s_2, w_1)$ and $\bar{a}(p^*, s_1, s_2, w_1)$ and let maximised expected profit be given by $\bar{\Pi}_1(p^*, s_1, s_2, w_1)$.

Applying the implicit function theorem yields the following comparative static results

$$\frac{\partial \bar{q}_1}{\partial p^*} = -p'(\bar{a}) \cdot \left( \frac{\bar{\Pi}_2(1) - \bar{\Pi}_2(0)}{\bar{\Pi}_2(1) - \bar{\Pi}_2(0)} \right) \cdot \frac{\nu'(\bar{a})}{\nu(\bar{a})} > 0, \quad (3.8)$$

$$\frac{\partial \bar{a}}{\partial s_1} = -\rho'(\bar{a}) \cdot \frac{\bar{q}_2(1) \cdot f'(\bar{q}_1)}{\bar{\Pi}_2(1) - \bar{\Pi}_2(0)} > 0, \quad (3.9)$$

$$\frac{\partial \bar{q}_1}{\partial s_2} = \left( \frac{\rho(\bar{a}) \cdot f'(\bar{q}_1)}{\bar{\Pi}_2(1) - \bar{\Pi}_2(0)} \right) \cdot \frac{-\rho'(\bar{a}) \cdot \bar{q}_2(1) \cdot f'(\bar{q}_1) - \nu'(\bar{a})}{\nu(\bar{a})} > 0, \quad (3.10)$$

$$\frac{\partial \bar{a}}{\partial s_2} = \left( \frac{\rho(\bar{a}) \cdot f'(\bar{q}_1)}{\bar{\Pi}_2(1) - \bar{\Pi}_2(0)} \right) \cdot \frac{\rho(\bar{a}) \cdot f'(\bar{q}_1) \cdot \bar{q}_2(1) \cdot f'(\bar{q}_1)}{\bar{\Pi}_2(1) - \bar{\Pi}_2(0)} > 0, \quad (3.11)$$

$$\frac{\partial \bar{q}_1}{\partial w_1} = \frac{\rho'(\bar{a}) \cdot \bar{q}_2(1) \cdot f'(\bar{q}_1)}{\bar{\Pi}_2(1) - \bar{\Pi}_2(0)} > 0, \quad (3.12)$$

$$\frac{\partial \bar{a}}{\partial w_1} = \frac{\rho(\bar{a}) \cdot f'(\bar{q}_1)}{\bar{\Pi}_2(1) - \bar{\Pi}_2(0)} > 0, \quad (3.13)$$
where $|J|$ is the Jacobian determinant which by the second order conditions for a maximum is greater than zero.

These comparative statics results are what one would expect. An increase in $\tilde{q}_1$, in turn, decreases the marginal expected profit $p$ and causes $\tilde{a}$ to rise. An increase in $s_1$ also increases both $\tilde{q}_1$ and $\tilde{a}$ because it increases the marginal expected profit of $p$ and $q_1$. Finally, an increase in $w_1$ increases $\tilde{a}$, in turn, increases the marginal expected profit of $q_1$ and causes $\tilde{q}_1$ to rise.

3.2. The Policy Maker's Problem

The policy maker's problem is to maximize welfare by choosing $s_1$, $s_2$, and $w_1$, subject to the constraint that if it is optimal for the domestic firm to produce, then the domestic firm must make at least zero economic profit. It is assumed that the policy maker can commit to $s_2$ in Period 1, otherwise, after the learning-by-doing has occurred it is optimal for the policy maker to set $s_2 = 0$ as a positive $s_2$ reduces Period 2 net profit. The measure of welfare used is the sum of expected profit and the expected external benefit of learning-by-doing minus the sum of all expected per unit subsidies. This welfare measure ignores distribution considerations and also ignores consumer surplus because the price in the domestic economy is fixed at the world price.

The constraint can be satisfied by making a lump sum payment to the firm. This payment has no welfare significance because distribution considerations are being ignored. As a result, this constraint will be ignored in the formal analysis of the policy maker's problem as it has no operational consequence other than requiring a lump sum payment.

The policy maker's problem is

$$\max_{s_1, s_2, w_1} \{ W^E = \Pi^E(\cdot) + B^E - s_1 \cdot \tilde{q}_1 - w_1 \cdot \tilde{a} - s_2 \cdot (\rho(\tilde{a}) \cdot \tilde{q}_1(1) + (1 - \rho(\tilde{a})) \cdot \tilde{q}_1(0)) \}$$ (3.14)

where $B^E$ denotes the expected external benefit and $\tilde{q}_1$ and $\tilde{a}$ are shortened version of $\tilde{q}_1(p^*, s_1, s_2, w_1)$ and $\tilde{a}(p^*, s_1, s_2, w_1)$ respectively. It is assumed that the external benefit in an increasing function of the amount of learning-by-doing obtained in the industry of concern and is given by $B = B(\theta \cdot f(q_1))$, where $B(\cdot) > 0$ and $B(\theta \cdot f(q_1)) = 0$ if $\theta = 0$. As a result, $B^E = \rho(\tilde{a}) \cdot B(f(\tilde{q}_1))$.

After applying the envelope theorem, the first order conditions for a maximum to this problem are

$$\frac{\partial W^E}{\partial s_1} = \left( \rho(\tilde{a}) \cdot B'(\cdot) \cdot f'(\cdot) - s_1 - s_2 \cdot \rho(\tilde{a}) \cdot \frac{\partial \tilde{q}_1}{\partial \tilde{q}_1} \right) \cdot \frac{\partial \tilde{q}_1}{\partial s_1} = 0$$

$$\frac{\partial W^E}{\partial s_2} = -s_2 \cdot \rho(\tilde{a}) \cdot \frac{\partial \tilde{q}_1}{\partial \tilde{q}_1} + (1 - \rho(\tilde{a})) \cdot \frac{\partial \tilde{q}_1}{\partial s_2} = 0$$

and

$$\frac{\partial W^E}{\partial w_1} = \left( \rho(\tilde{a}) \cdot B'(\cdot) \cdot f'(\cdot) - s_1 - s_2 \cdot \rho(\tilde{a}) \cdot \frac{\partial \tilde{q}_1}{\partial \tilde{q}_1} \right) \cdot \frac{\partial \tilde{q}_1}{\partial w_1} = 0$$

(3.15)

The intuition behind each of these conditions is similar. Increases in $s_1$, $s_2$, and $w_1$ increase $\tilde{q}_1$ and $\tilde{a}$. In turn, increases in $\tilde{q}_1$ and $\tilde{a}$ have two counteracting effects on expected welfare. The first is that expected welfare tends to rise because the expected learning spillover increases and the second is that expected welfare tends to fall because the expected total subsidy payment rises. At the solution to the first order conditions, these counteracting effects are balanced at the margin. Let the solution to Problem 3 be given by $\tilde{s}_1$, $\tilde{s}_2$, and $\tilde{w}_1$. 

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Proposition 1: The symmetric information solution to the policy maker's problem involves \( \tilde{s}_1 = 0 \). The optimal Period 1 output subsidy is set equal to the expected marginal externality of output, at the optimal solution, and the optimal Period 1 effort subsidy is set equal to the expected marginal externality of effort, at the optimal solution.

Proof. Rearranging (3.16) yields

\[
\left( \rho'(\hat{\theta}) \cdot B'(\cdot) \cdot f'(\cdot) - s_1 - s_2 \cdot \rho(\hat{\theta}) \cdot \frac{\partial \hat{\theta}}{\partial \hat{\theta}_1} \right) = \frac{\left( \rho'(\hat{\theta}) \cdot B(\cdot) - w_1 - s_2 \cdot \left( \rho'(\hat{\theta}) \cdot \left( \hat{\theta}_1 - \hat{\theta}(0) \right) \right) \right) \cdot \frac{\partial \hat{\theta}}{\partial \hat{\theta}_1}}{\frac{\partial \hat{\theta}}{\partial \hat{\theta}_1}}.
\]

Substituting this into (3.17) and rearranging gives

\[
\left( \rho'(\hat{\theta}) \cdot B(\cdot) - w_1 - s_2 \cdot \left( \rho'(\hat{\theta}) \cdot \left( \hat{\theta}_1 - \hat{\theta}(0) \right) \right) \right) \cdot \left( \frac{\partial \hat{\theta}}{\partial \hat{\theta}_1} \cdot \frac{\partial \hat{\theta}}{\partial \hat{\theta}_2} \right) = s_2 \cdot \left( \rho'(\hat{\theta}) \cdot \left( \hat{\theta}_1 - \hat{\theta}(0) \right) \right).
\]

From the comparative static results

\[
\left( \frac{\partial \hat{\theta}}{\partial \hat{\theta}_1} \cdot \frac{\partial \hat{\theta}}{\partial \hat{\theta}_2} \right) = 0,
\]

so \( \tilde{s}_2 = 0 \).

Given \( \tilde{s}_2 = 0 \), and combining (3.18) and (3.16) yields

\[
-(\rho'(\hat{\theta}) \cdot B(\cdot) - w_1) \cdot \left( \frac{\partial \hat{\theta}}{\partial \hat{\theta}_1} \cdot \frac{\partial \hat{\theta}}{\partial \hat{\theta}_2} \right) = 0.
\]

From the comparative static results

\[
\left( \frac{\partial \hat{\theta}}{\partial \hat{\theta}_1} \cdot \frac{\partial \hat{\theta}}{\partial \hat{\theta}_2} \right) \neq 0,
\]

which implies that

\[
\tilde{w}_1 = \rho'(\hat{\theta}) \cdot B(\cdot),
\]

and

\[
\tilde{s}_1 = \rho(\hat{\theta}) \cdot B'(\cdot) \cdot f'(\cdot).
\]

(Q.E.D.)

The intuition behind Proposition 1 is quite simple. There are three choice variables for the policy maker, \( s_1, s_2 \), and \( w_1 \), but only two target variables, \( \eta_1 \) and \( \eta_2 \). Therefore, one of the choice variables is redundant and since \( s_1 \) and \( w_1 \) have a more direct effect on the target variables than \( s_2 \), the theory of distortions [Corden (1974) and Bhagwati (1971)] suggests that \( s_2 \) be made redundant.

One implication of Proposition 1 is that temporary assistance, in the form of Period 1 subsidies on output and effort, is optimal rather than permanent assistance, in the form of output subsidies in both periods. This is despite the fact that a Period 2 output subsidy gives the firm an incentive to increase learning, as can be seen from the comparative static results.

Another implication of Proposition 1 is that the assumption regarding the policy maker being able to commit to a Period 2 subsidy in Period 1 is not operational, as \( \tilde{s}_2 = 0 \) at the solution to the policy maker's problem.

4. Asymmetric Information

In this section, it is assumed that the policy maker is unable to observe the effort of the owner/manager and as a result is unable to directly subsidise effort. That is, \( w_1 \) is no longer a choice variable for the policy maker. The policy maker can only give per unit subsidies on variables it can observe. One question addressed in this section is whether under these information conditions it is still optimal to set \( \tilde{s}_2 = 0 \), especially since the comparative static results imply that \( s_2 \) and \( w_1 \) have similar effects on Period 1 output and effort.

Three cases will be considered. The first is where the policy maker can commit to a Period 2 output subsidy in Period 1. The second is where no such commitment is possible
and the third is where the policy maker can commit to a Period 2 lump-sum subsidy which is contingent on Period 2 output.

4.1. Commitment to Period 2 Output Subsidy

In this section, it is assumed that the policy maker can commit to a Period 2 output subsidy in Period 1.

4.1.1. The Firm's Problem

The firm's problem is identical to Problem 2 of Section 3 except the term associated with $w_1$ does not appear in the objective function. Let the solution to the firm's problem be given by $q_1(p^w, s_1, s_2), q_3(p^w, s_1, s_2)$, and $\bar{a}(p^w, s_1, s_2)$, and let maximised Period 2 profit and expected profit be respectively given by $\bar{f}_1(q_1, \bar{a}, p^w, s_1, s_2)$ and $\bar{f}_2(p^w, s_1, s_2)$.

The comparative static results are qualitatively the same as (3.8) to (3.13) in Section 3, except they are calculated at $\bar{a}, q_1, \bar{f}_1(1), \bar{f}_2(0)$, and $\bar{f}_2$. The intuition for these results is the same as in Section 3.

4.1.2. The Policy Maker's Problem

The policy maker's problem is identical to Problem 3 of Section 3, except the term associated with $w_1$ does not appear in the objective function and $w_1$ is no longer a choice variable. The first order conditions for a maximum are qualitatively the same as (3.16) and (3.17) in Section 3, except they are calculated at $q_1(1), \bar{q}_1(0), \bar{q}_1$, and $\bar{a}$.

Proposition 2: The asymmetric information solution to the policy maker’s problem, where the policy maker can commit to a Period 2 output subsidy in Period 1, involves $\delta_1 = 0$. The optimal Period 1 output subsidy is set greater than the expected marginal externality of output at the optimal solution.

Proof: Combining the first order conditions of the policy maker's problem yields a qualitatively similar condition to (3.20) in Section 3. Namely,

$$\rho'(\delta) \cdot \left( H(-) \cdot s_2 \cdot (q_3(1) - \bar{q}_3(0)) \right) \cdot \left( \frac{\partial \bar{f}_1}{\partial s_2} \right) = \delta_1 \cdot \frac{\partial \bar{f}_1}{\partial \delta} - \delta_1 \cdot \frac{\partial \bar{f}_1}{\partial \delta} \cdot (q_3(1) - \bar{q}_3(0)).$$

From the comparative static results

$$\left( \frac{\partial \bar{f}_1}{\partial \delta} \right) \left( \frac{\partial \bar{f}_1}{\partial \delta} \right) = 0,$$

so $\delta_1 = 0$.

Given $\delta_1 = 0$, the first order condition associated with $\delta_2$ becomes

$$\rho'(\delta) \cdot H(-) \cdot f'(-) \cdot \delta_2 \cdot \frac{\partial \bar{f}_1}{\partial \delta_2} + \rho'(\delta) \cdot H(-) \cdot \delta_2 \cdot \frac{\partial \bar{f}_1}{\partial \delta_2} = 0.$$

Now $H(-) > 0$, so $\rho'(\delta) \cdot H(-) \cdot f'(-) \cdot \delta_2 \cdot s_2 < 0$. This implies that

$$\delta_2 > \rho'(\delta) \cdot H(-) \cdot f'(-).$$

(Q.E.D.)

As a result, $\delta_2$ is set greater than the size of the externality associated with $q_1$ in order to get a closer to its desired level.

It may seem surprising that one of the choice variables available to the policy maker is set equal to zero when only two choice variables are available. However, the intuition for $\delta_2 = 0$ comes from there being a first order benefit, but only a second order cost from decreasing $s_2$, where $s_2 > 0$. A decrease in $s_2$ decreases $q_3(1), q_3(0), q_1$, and $\bar{a}$, which results in a first order benefit of

$$s_2 \cdot \frac{\partial q_1}{\partial s_2} = s_2 \cdot \left( \rho(\delta) \cdot \frac{\partial f_2(1)}{\partial s_2} + (1 - \rho(\delta)) \cdot \frac{\partial f_2(0)}{\partial s_2} \right),$$

and a second order net cost of

$$\left( \rho(\delta) \cdot H(-) \cdot f'(-) \cdot s_2 \cdot \frac{\partial q_1}{\partial \delta} \right) \cdot \frac{\partial f_2(1)}{\partial s_2} + \left( \rho(\delta) \cdot H(-) \cdot \frac{\partial f_2(1)}{\partial s_2} \cdot (q_3(1) - \bar{q}_3(0)) \right) \cdot \frac{\partial f_2(0)}{\partial s_2}.$$

As $\delta_2 = 0$, there is no need to consider the case where the policy maker can not commit to a Period 2 per unit output subsidy.
4.2. The Policy Maker's Period One Problem With Contingent Lump-Sum Subsidies

It is assumed that the policy maker can commit in Period 1 to a Period 2 lump-sum subsidy which is contingent on Period 2 output of \( q_1 \). This is a variation on a mechanism first suggested by Loech and Magat (1979) and essentially involves changing the domestic firm's objective function so that it coincides with that of the policy maker.\(^6\)

Proposition 3: In the presence of asymmetric information, if a Period 2 lump-sum subsidy equal to \( B(f(q_1, \hat{q}_1, \hat{w}_1)) \) is paid to the firm contingent on Period 2 output being \( \hat{q}_1 \) and an output subsidy of \( \hat{q}_1 \) is paid in Period 1, then the symmetric information solution is attainable.

Proof. In Period 2, the probability of output being \( \hat{q}_1 \) is \( \rho(u) \). Therefore, in Period 1, the domestic firm receives \( B(f(q_1, \hat{q}_1, \hat{w}_1)) \) with probability \( \rho(u) \). The firm's Period 1 problem becomes

\[
\max_{s_1} \left[ \Pi^p(u, q_1, w_1, s_1, s_2, w_2) = p^w \cdot q_1 - c(s_1) + s_1 \cdot q_1 + \rho(u) \cdot \Pi^p(1) \right. \\
\left. + (1 - \rho(u)) \cdot \Pi^p(0) - v(s_1) + \rho(u) \cdot B(f(q_1, \hat{q}_1, \hat{w}_1)) \right].
\]

(4.7)

Assuming an interior solution, the first order conditions for a maximum are

\[
\frac{\partial \Pi^p(u)}{\partial s_1} = p^w \cdot q_1 - c(s_1) + s_1 \cdot q_1 + \rho(u) \cdot B(f(q_1, \hat{q}_1, \hat{w}_1)) = 0
\]

(4.8)

and

\[
\frac{\partial \Pi^p(u)}{\partial q_1} = p^w - c(s_1) + s_1 + \rho(u) \cdot f(q_1) - \hat{q}_1 = 0.
\]

(4.9)

If \( \hat{q}_1 \) and \( \hat{q}_1 \) are substituted into first order conditions (3.6) and (3.7), then conditions (4.8) and (4.9) are identical to (3.6) and (3.7) at \( q(\hat{q}_1, \hat{w}_1) \) and \( \hat{q}_1(\hat{q}_1, \hat{w}_1) \). (Q.E.D.)

5. Conclusion

This paper has explicitly considered the incentive effects of permanent compared to temporary infant industry assistance. To do this a two period model was developed in which a dynamic external economy, in the form of learning-by-doing spillovers, provided the rationale for assistance. The incentive effects of this assistance were examined by introducing owner/manager effort into the learning process.

It was shown that under conditions of asymmetric information, where the policy maker could observe owner/manager effort, that temporary assistance, in the form of first period per unit output and effort subsidies, was optimal.

Under conditions of asymmetric information, where the policy maker could not observe owner/manager effort and was restricted to per unit output subsidies, it was shown that temporary assistance, in the form of a first period per unit output subsidy, was optimal. Where the policy maker could commit to a Period 2 lump-sum subsidy contingent on Period 2 output as well as a Period 1 per unit output subsidy, it was shown that this form of permanent assistance was optimal. In fact, this form of assistance can duplicate the symmetric information solution. This last result suggests more care is needed in designing...
infant industry assistance, in the presence of asymmetric information, because, to the
authors' knowledge, no infant industry assistance package contains contingent lump-sum
subsidies.

More research needs to be done in this area and some natural extensions to this paper
include examining the effect of risk aversion as well as the effect of separation of ownership
and control.

REFERENCES

Baldwin, R.E., “The Case Against Infant Industry Protection,” Journal of Political Econ-
omy, 77, June 1969, 295–305.

K.W. Jorges, and J. Vaneck (eds.) Trade, Balance of Payments, and Growth: Essays in

Corden, W.M., Trade Policy and Economic Welfare, (Oxford: Oxford University Press,
1974).

Fudenburg, D., and J. Tirole, “Learning—By—Doing and Market Performance,” Bell Jour-

Kemp, M.C., “The Mill—Bastable Infant—Industry Dogma,” Journal of Political Econ-


Laffont, J.J., and J. Tirole, “Using Cost Observation to Regulate Firms,” Journal of Politi-

Loeb, M., and W.A. Megat, “A Decentralised Method For Utility Regulation,” Journal of
Law and Economics, 22, October 1979, 399–404.

Matsumiya, K., “Perfect Equilibria in a Trade Liberalization Game,” American Economic
Review, 80, June 1990, 480–492.

Speake, A.M., “The Learning Curve and Competition,” Bell Journal of Economics, 12,
Spring 1981, 49–70.

Sussal, P., “The Need For Industrial Policies in LDC’s—A Restatement of the Infant

Wright, D.J., “Hidden Action and Learning—By—Doing in Models of Monopoly Regulation
and Infant Industry Protection,” University of Sydney, Department of Economics
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N.V. Lam, *Journal of the Developing Economies*, 17(1), March 1975


I.G. Sharpe, *Journal of Banking and Finance*, 3(1), April 1979


V.B. Hall, *Economic Record*, 56(157), March 1980


P.D. Groenewegen, *Economic Record*, 57(159), December 1981

J. Yates, *A.P.S.E., Commissions and Studies*, 2, 1982


V.B. Hall & F. Saunders, *Economic Record*, 60(161), March 1984

F. Gill, *Economic Record*, 59(166), September 1983


W.J. Merrilees, *Australian Quarterly*, 56(3), Spring 1984

J. Yates, *Economic Record*, 59(166), September 1983


V.B. Hall, *Australian Quarterly*, 59(2), Winter 1987

W.J. Merrilees, *Economic Record*, 56(2), Winter 1984


J. Biggott, *Public Sector Economics, 0-1 Reader*, P. Hare (ed.), Basil Blackwell, 1988

P. Hare (ed.), *Blackwell Educational Economics* (1), 1990


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T. P. Truong &  
V. A. Nguyen  
Energy Economics, 12(4) October 1990  
114 V. B. Hall,  
T. P. Truong & V. A. Nguyen  
Australian Economic Review, 37(1) 1989  
115 P. Gill  
116 G. Kingston  
117 V. B. Hall &  
D. R. Mills  
Pacific and Asian Journal of Energy, 2(2),  
December 1998  
118 W. P. Hogan  
Abacus, 25(2), September 1989  
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Flattening the Tax Rate Scale: Alternative  
Scenarios & Methodologies, (eds.) J.G. Head  
and R. Krever, 2, 1-31, 1990  
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I. C. Sharpe  
Economic Analysis and Policy, 19(1),  
March 1989  
123 G. Mills  
Journal of Transport Economics and Policy,  
21, May 1989  
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The Australian Quarterly, 61(4), 1989  
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J. Sheen  
The Economic Journal, 100(400), 1990  
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