THE AUSTRALIAN EXPORT EXPANSION GRANTS SCHEME*

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A B S T R A C T

Under the Export Expansion Grants Act of 1978, certain groups of Australian exporters are eligible for a governmental grant on their incremental export revenues, at rates which decrease with the absolute magnitude of the export increment. We have shown elsewhere that a marginal export subsidy may result in cyclical export fluctuations (Kleinman and Fincus, 1980a). It is shown here that the regressiveness of the EEG subsidy pattern generates cycles of varying amplitude and duration, depending on the characteristics of individual firms. It is also shown that the EEG scheme offers, in effect, a higher range of subsidy rates to small firms and to those which already export a high proportion of their output.
THE AUSTRALIAN EXPORT EXPANSION GRANTS SCHEME
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E. Kleiman and J.J. Pincus

I. INTRODUCTION

The Export Expansion Grants Scheme (EES, for short) was introduced by the Australian Commonwealth Government in November 1978. Its objective was "to provide a further significant boost to export activity", supplementing the promotional effects of the Export Market Developments Grants Act, which was amended at the same time (Department of Trade and Resources, n.d.).

The EES, which is administered by the Export Development Grants Board established in 1974, provides for the payment of grants "to residents of Australia, who increase export earnings from the export of: goods, services, internal services, industrial property rights, and know-how" (ibid, p.32).

The grant, which is taxable, is payable on "the amount by which the grant year export earnings exceed the moving base period export earnings", the latter being defined as "equal to one-third of the sum of the export earnings in the 3 years immediately preceding the grant year" (p.34). (A somewhat different definition applies to cases where there have been no export earnings in one or more of the base-period years.) The rate at which the grant is paid decreases with the size of the export earnings increment, from 15 per cent on the first $0.5 million, to 10 per cent on the next $4.5 million, 5 per cent on the following $5.0 million, tapering off to 2.5 per cent on all further export increments. Only goods with an 'Australian content' of at least 50 per cent of their export sales value can qualify for the grant. Exports of minerals and of most farm produce are not eligible, nor are tourist services. But the Export Development Grants Board has considerable leeway for discretionary action in interpreting the requirement for a 'substantial' Australian content, and in adjusting the export base figures, in excess of which the grant is paid if, "by reason of abnormal
trading conditions ... beyond the control of the claimant, the amount of the export earnings of the claimant for that [base period] year ... is greater than it would otherwise have been" (EEG Act, 1978, 7(2)).

The EEG scheme differs from an ordinary export subsidy scheme in three ways. First, subsidies are not paid on all export revenue, but only on the excess over some base level: the EEG is a 'marginal' export subsidy scheme. (The marginal nature of the scheme is designed to reduce the redundant or infra-marginal subsidy payments, thereby reducing the Treasury's cost for a given increase in exports.) Next, the export base is not fixed, but moves with export performance. A theoretical analysis of schemes combining these two attributes, moving-base marginal export subsidies, with special reference to the scheme recommended by the Crawford Committee (1979) is the subject of an earlier paper (Kleinman and Pincus, 1980a). Last, the rate of subsidy is not constant, but regressive as outlined above.

In Section II we establish that the EEG scheme will produce fluctuations in the exports of individual firms: an export cycle in fact. Unlike the Crawford Committee's scheme, the cycle generated by the EEG is not a simple, regular and symmetrical one, and will vary from firm to firm in a manner analyzed in Section III. There we show that the EEG scheme, in practice, offers a higher range of subsidy rates to small firms and to firms with low export supply elasticities, that is, to firms less capable of expanding exports cheaply. Though the scheme aims explicitly at firms with little exports, or none at all (IAC, 1978, p.73), we will show that, in effect, it offers a higher incentive to those which already export a high proportion of their output. Some numerical examples of the expected effects of the EEG scheme are provided in Section IV.

II. GENERATING THE CYCLE

1. The Initial Export Expansion

How does a subsidy scheme on EEG lines affect the decisions of the
individual exporter? In a small country context we may assume the firm to be faced with perfectly elastic foreign demand, at a given world price, $P_f$—see Figure 1. With this price constant, export revenue is proportionate to the volume of exports and, for expository convenience, we shall conduct the analysis in terms of the latter. Let the firm's export supply curve—which represents either or both the costs of production and the revenue foregone on the domestic market—be $S_E$ or $S'_E$. Without a subsidy, the level of exports is $X_0$. The EGEC scheme offers various subsidy rates on any exports greater than a specified export base level, with the highest subsidy rate, $s_1$, applying only to the first $\Delta_1$ of exports above the base (which in the first year is $X_0$ itself); $s_2 < s_1$, applying to the next $\Delta_2$ of exports; and so on. The marginal export revenue curve then assumes the shape of a step function, drawn in Figure 1 as a solid line finally flattening out at the level $(1+s_4)P$; corresponding to the lowest subsidy rate, $s_4$, which is payable on all exports in excess of $\frac{1+s_4}{1+s_1}$.

1. In another paper, Kleiman and Pincus (1980c), we consider the effects of an export subsidy on firms not always in the export market.
For the firm with the flatter export supply curve, $S_E$, exports of $X(s_2)$ are more profitable than exports of $X_0$, with the extra profits being shown by the area bounded from below by the segment $BC$ of the supply curve and above by the subsidy block. Similarly, the firm with the steeper supply curve, $S_E'$, will find $X(s_1)$ more profitable than $X_0$. We will write $X(s_1)$ to indicate the level of exports that the firm would choose if the world price were $(1+s_1)p$ or, alternatively, if an ordinary export subsidy had been offered and accepted at a rate $s = s_1$. The highest possible export level, corresponding to the highest subsidy rate, is $X(s_1)$. Notice that in this first year the higher marginal subsidy rate is obtained by the firm with the lower export supply elasticity. Subsequently, we will show that the firm with the flatter (more elastic) supply may never get to take advantage of the highest subsidy rate or, possibly, not even of any rate higher than the one it enjoys in the first year. For our present purposes, however, it is sufficient that in the first year of operation of the EEC scheme all exporting firms increase their exports by different absolute and relative amounts.

What are these amounts? Most Australian manufacturing firms do not cater exclusively for foreign markets. They thus sell also on the domestic market, in which we assume the individual producer to enjoy some monopoly position. To maximize his profits, the producer will equate the marginal revenues obtainable from sales in either market with his marginal costs. His export supply curve is the difference between the total quantities supplied by him at various given prices, and those which he then finds profitable to sell on the domestic market. We shall denote the elasticity of this supply curve by

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2. Most potentially exportable manufactures are either branded goods or such as steel, with a high degree of monopoly power in the local market, which may be due to either or both transportation costs and a protective tariff.
\[ \theta = \frac{\zeta - (1-\alpha)\eta}{\alpha} \]  

where \( \zeta \) is the elasticity of the total (production) supply curve, 
\( \alpha \) is the share of exports in output, 
and \( \eta \) is the elasticity of the domestic marginal revenue curve. The 
export curve \( X(s_1) \), then, can be written as \( X(s_1) = X_0 + s_1 \Delta X_0 \).

3. Strictly, \( \theta \) is the arc elasticity over the relevant range. If \( e \) is the 
ordinary demand elasticity of the demand curve \( q = f(p) \), and \( f'(p) \) are 
\( f''(p) \) the appropriate derivatives, then \( \zeta = (1+e)/(2+ q f''(p)/f'(p)) \).

2. Exports and Bases

The export base in the EEG scheme, as in the alternative proposed by 
the Crawford Committee, moves with export performance. And, in turn, 
the level of the base determines the level of export in a manner we will 
now uncover.

Putting temporarily aside questions of the mechanism by which the base 
is moved, as well as questions of profitability, examine the effect of 
sliding the subsidy block horizontally to the right. Two bases are shown 
in Figure 2, \( B_a \) and \( B_b \); for convenience, the world price has been set at 
unity. The relevant points of intersection of the supply curve with the 
corresponding subsidy block portion of the marginal revenue curve are \( G \) 
and \( G_b \) respectively. The export level corresponding to \( G \) is \( X(s_2) \).

Note that \( X(s_2) \) falls between \( B_a + \Delta_1 \) and \( B_a + (\Delta_1 + \Delta_2) \). In general, for 
\( X(s_1) \) to be the appropriate export level for any base \( B_a \), we need

\[ B_a + \sum_{k=1}^{i-1} \Delta_k \leq X(s_1) \leq B_a + \sum_{k=1}^{i} \Delta_k \]  

Expression (2) can be usefully rearranged as follows:

\[ X(s_1) - \sum_{k=1}^{i-1} \Delta_k \leq B_a \leq X(s_1) - \sum_{k=1}^{i} \Delta_k \]
That is to say, there is a range of bases all of which would give rise to the same level of exports, \( X(s_i) \); the width of this range is \( \Delta_i \). It will prove convenient and revealing to express the base in terms of the highest possible level of exports \( X(s_i) = X_0 + s_1 \delta X_0 \) referred to earlier, by defining

\[
\lambda_i = \frac{B_c - X_0}{s_1 \delta X_0}
\]

That is, any base can be expressed as an average of \( X_0 \) and \( X(s_i) \), such that:

\[
B_c = (1 - \lambda_i) X_0 + \lambda_i X(s_i)
\]

\[
= (1 + \lambda_i) s_1 \delta X_0
\]

Using this transformation, expression (3) becomes

\[
\frac{s_1}{s_1} - \sum_{k=1}^{i-1} \frac{\delta_k}{\delta X_0} \leq \lambda_i \leq \sum_{k=1}^{i-1} \frac{\delta_k}{\delta X_0}
\]

(3a)

Consider now \( B_b \), \( C_b \) and \( X_b \). The export supply curve intersects the subsidy block between the \( s_i \) and the \( s_{i-1} \) levels at \( C_b \). The level of exports corresponding to \( C_b \) is \( X_b = B_b + \Delta_i \). In general, for intersection between the \( s_i \) and the \( s_{i-1} \) levels, exports are given by

\[
X_c = B_c + \sum_{k=1}^{i-1} \delta_k
\]

(4)

Once again, there is a range of bases all of which produce an intersection between the \( s_i \) and \( s_{i-1} \) levels of the subsidy block, given by

\[
X(s_i) = \sum_{k=1}^{i-1} \delta_k < B_c < X(s_{i-1}) - \sum_{k=1}^{i-1} \delta_k
\]

(5)

In this case, however, each base producing such an intersection gives rise to a different export level, as (4) shows: as long as the intersection remains, like \( C_b \), on a vertical segment of the subsidy block, an increase
in $B_t$ produces an equal increase in $X_t$.\(^4\)

\[
\frac{s_1}{s_1} - \frac{1}{\sum_{k=1}^{i-1} \frac{\Delta_k}{s_1}} \times \frac{\Delta_k}{s_1} < \lambda_t < \frac{\frac{B_0 - X_0}{s_1}}{\sum_{k=1}^{i-1} \frac{\Delta_k}{s_1}} \quad (5a)
\]

\(^4\) The export level $X_t = B_t + \sum_{k=1}^{i-1} \Delta_k$ would have been produced by some ordinary subsidy rate $s$ such that $s_{i-1} > s > s_1$. In the EEG scheme, however, the marginal subsidy rate paid in the last dollar of $B_t + \sum_{k=1}^{i-1} \Delta_k$ is $s_{i-1}$, and on the next dollar beyond $B_t + \sum_{k=1}^{i-1} \Delta_k$ is $s_1$.\]
What if the base were equal to $X(s_1)$; that is, if the supply curve touched the subsidy block at point Q, Figure 27? The export level corresponding to point Q is $X(s_1)$ itself, so that $X(s_1)$ is both the highest relevant base and the highest possible level of exports.

The complete relationship between the level of the base and the level of exports corresponding to points of intersection between the supply curve and subsidy block, is shown in Figure 3 where the size of the base is measured along the horizontal axis, and export levels are measured along the vertical one. Points on the 45° ray through the origin are equi-distant from both axes. Thus, point Q in Figure 2, where $X_1 = B_t = X(s_1)$, maps into point Q in Figure 3. The solid line in Figure 3, ending at Q, shows the export levels which the firm will consider given the corresponding base. Thus, for example, with the base equal to the pre-subsidy level of exports, $B_0 = X_0$, the export supply curve is assumed here to intersect the marginal revenue curve at the latter's vertical segment between $s_4$ and $s_5$; and the level of exports the firm will be considering to become eligible for the subsidy is that corresponding on the vertical axis to point E in Figure 3. At the upper end of the solid line, for bases in the range of $X(s_1)$ down to $X(s_4) = \Delta_1$, exports remain at $X(s_1)$; this is the segment NQ in Figure 3, where condition (3) applies. Along the next segment, NW, exports fall dollar for dollar with the base; equation (4) and condition (5) apply. And so on.

It is important to remark how Figure 3 will differ for each different export supply curve. All graphs like Figure 3 will have ordered horizontal segments of length $\Delta_1$, connected by segments of unit slope. The lengths of these connecting segments depend on the average elasticity of the supply curve between the relevant export levels, $X(s_1)$ and $X(s_{4-1})$. Therefore, all graphs of the relationship between base and exports will be vertically-squeezed or stretched versions of that shown in Figure 3.
itself. Also, the origin will vary. For example, if we were to draw a figure like 3 for the steep supply curve $S_g'$ shown in Figure 1, its origin would move up to a point like $O'$ in the actual Figure 3.

3. The Critical Base

Not all of the export levels shown in Figure 2 will be profitable - in fact, we will demonstrate that at most only half of them are, in the linear case. To discover exactly why, reconsider Figure 2. The supply curve $S_g$ in Figure 2 cuts the marginal revenue curve at $E$, $F$ and $G$, when the subsidy block is tethered at $B_a$. The choice between $E$, $F$ and $G$ depends on profitability. First, note that exports corresponding to $F$ (that is,
exports of a level equal to \( B_a \) itself) must be less profitable than those corresponding to \( X \) (that is, exports of level equal to \( X_0 \)), because no subsidy at all is paid on any exports between \( X_0 \) and \( B_a \). The shaded area in Figure 2 shows the excess of the cost of production (or domestic revenue foregone) of the quantity \( B_a - X_0 \) over the unsubsidized sales receipts, \( X_0 \). If the firm decides to export \( X(s_2) \), corresponding to \( C \), this shaded area becomes a loss, to be weighed against the extra profits gained from the excess of the subsidy paid on \( X(s_2) \) - \( B_a \) over the uncovered costs of exporting \( X(s_2) - B_a \). This extra profit is represented by the hatched area above \( FG \).

When the two areas are equal, the firm will be indifferent between \( X_0 \) and \( X(s_2) \) in terms of the profit obtained in a year in which \( B_a \) is the export base level under the EEG scheme. We call 'critical' that base, \( B^* \), which makes the profit from exporting the subsidy-induced quantity of exports just equal to the profit from foregoing the subsidy and allowing exports to revert to their pre-subsidy level, \( X_0 \). As will become clear later, because of the way the EGG scheme shifts the base, the firm will in fact choose \( X_0 \) whenever \( B^*_t \geq B^* \): bases on or to the right of the dashed line labelled \( B^* \) in Figure 3 would result in exports of \( X_0 \).

It is now possible to see how the EGG scheme produces an export cycle. In the first year of the scheme, \( B^*_t = X_0 \), and a level of exports in excess of \( X_0 \) is profitable (see again Figure 1). Therefore, the base in the second year will be moved with export performance in the first year to some level in excess of \( X_0 \). As long as \( B^*_t < B^* \), exports will rise as shown in Figure 3 with increases in base. And so on until eventually \( B^*_t \geq B^* \).

5. We have developed the concept of the critical base in Kleiman and Fincus, 1980a.
upon which exports revert to $X_0$, only to start up again after some years at $X_0$. The detail of this cycle is examined in the remainder of the paper.

III. THE CYCLE IN DETAIL

1. The Critical Base

Because the export supply curve can cut the subsidy block on either a horizontal or a vertical segment, it is necessary to develop two separate expressions for the value of the critical base. In Figure 2, the export supply curve $S_e$ intersects at $G$ the subsidy block tethered at $B_a$; the relevant marginal subsidy is $s_2$. If the firm decides to export $X(s_2),$ the hatched gain area can be decomposed into two parts: $FGI,$ which is the excess of the subsidy revenue at the effective marginal rate, over the incremental costs of supplying the exports $X(s_2) - B_a$; and the remainder, the hatched area above $FG$. The first component will be equal to some proportion, $\gamma$, of the rectangular area $[s_2 - (B_a - X_0)/\delta X_0][X(s_2) - B_a]$, where $\gamma$ depends on the curvature of the $S_e$ curve between $B_a$ and $X(s_2)$. The second gain component is equal to the excess of the subsidy rate actually paid on the first export increment, over the relevant marginal one, $(s_1 - s_2)\Delta_1$. And the loss area $HF$, due to no subsidy being paid on the excess of the base over the pre-subsidy export level is equal to some proportion $(1-\delta)$, of the rectangular area $[(B_a - X_0)/\delta X_0)(B_a - X_0),$ where $\delta$ depends on the curvature of the $S_e$ curve between $X_0$ and $B_a$. Given this base, therefore, the firm will opt to become eligible for the subsidy by exporting $X(s_2)$ only if

$$\left((s_1 - s_2)\Delta_1 + \gamma \left(s_2 - \frac{B_a - X_0}{\delta X_0}\right)[X(s_2) - B_a] - (1-\delta) \frac{(B_a - X_0)^2}{\delta X_0} > 0 \right.$$  \hspace{1cm} (6)

otherwise it will revert to $X_0$.

6. With subsidized exports, in this case $X(s_2)$, equally profitable as $X_0$, the firm will be indifferent between exporting $X(s_2)$ and $X_0$ in year $t$. But taking into consideration the effect on $B_{z+1}$, it will then prefer to revert to $X_0$.  
More generally, when the supply curve, $S_B$, cuts the horizontal portion of the subsidy block at level $s_1$, the critical base can be found from the following profit expression

$$
\sum_{k=1}^{\frac{1}{\gamma}} \left( s_1 - s_1 \lambda_1 + \gamma(s_1 - \frac{B - X_0}{s_0}) \right) \left( X(s_1) - B \right) - (1-\gamma) \frac{(B - X_0)^2}{s_0} \geq 0 \tag{7}
$$

Because profit is non-increasing in $s_1$, there can be at most one value of $B = B^*$ for which (7) becomes an equality. That is, at most one combination of $s_1$ and $B$ will exactly satisfy (7), given $\gamma$ and $X_0$. As Figure 3 illustrates, there will generally be a range of bases for which $X(s_1)$ is profitable, and $B^*$ is the highest in that range.

Substituting $X(s_1) = X_0 + s_1 s_0 X_0$, and $\lambda s_1 = (B - X_0)/s_0$, we may identify that value of $\lambda = \lambda^*$ which just satisfies condition (7). We shall call $\lambda^*$ the critical value of $\lambda$, which expresses the critical base in terms of the export level associated on the export supply curve with the highest subsidy rate offered under the scheme, $X(s_1)$.

$$
B^* = (1 + \lambda^* s_1 s_0) X_0
$$

In the linear case, where $\gamma = (1-\delta) = \delta$, this critical value becomes

$$
\lambda^* = \frac{1}{2} \frac{s_1}{s_1} + \sum_{k=1}^{\frac{1}{\delta}} \left( \frac{s_k}{s_1} - 1 \right) \frac{\Delta s_k}{s_0} \tag{8}
$$

It may, of course, happen that all the values of $\lambda$ in the range defined by (8) for a given $i$ fall short of $\lambda^*$ (or that all of them exceed it). Then, all bases for which $s_1$ is the subsidy rate relevant at the margin are profitable, and when faced with the choice of exporting $X(s_1)$ and $X_0$, the firm will always prefer the higher of these two export levels (or, in the opposite case, no such base is ever profitable, and reverting to $X_0$ will always be preferred to exporting $X(s_1)$). Thus, $\lambda^*$ determines the maximum level of exports the firm will attain under the subsidy scheme.
The value of \( \lambda^* \) is the result of the interaction between the characteristics of the firm, represented here by \( \partial X_0 \), and the parameters of the EGO scheme. Many firms will find that \( X(s_1) \) is their highest profitable export level. Of course, the value of \( X(s_1) \) will not be a constant across firms, but will depend on the shape of each firm’s supply curve. In other words, there will be a range of \( \partial X_0 \) for which \( X(s_1) \) is the value of exports corresponding to the critical base. This range of \( \partial X_0 \) can be found by substituting the solution for \( \lambda^* \) from equation (8) into expression (9), yielding:

\[
2 \sum_{k=1}^{1} \frac{s_k \lambda_k}{(s_1^2)} \leq \partial X_0 \leq 2 \sum_{k=1}^{1} \frac{s_k \lambda_k}{(s_1^2)}
\]

The values of the ranges for \( \partial X_0 \) are listed in Table 1, to which we turn shortly.

The critical base need not of course necessarily correspond to any one of the subsidy block’s horizontal segments. In the other case illustrated in Figure 2, the export supply curve intersects the subsidy block, originating at \( B_b \), at one of the vertical segments, between \( s_1 \) and \( s_2 \). If profitable, the level of exports would be \( B_b + \Delta_1 \). In general, exports of \( B + \sum_{k=1}^{i-1} \lambda_k \) are profitable if

\[
\sum_{k=1}^{i-1} \frac{\Delta_k + (B - X_0)}{\partial X_0} \Delta_k + \gamma \sum_{k=1}^{i-1} \frac{\Delta_k}{\partial X_0} > (1 - \delta) \frac{(B - X_0)^2}{\partial X_0} > 0
\]

where \( \gamma \) and \( \delta \) now reflect the curvature of \( X_k \) between \( B \) and \( B + \Delta_1 \), and between \( X_0 \) and \( B \), respectively. Once again, the critical base is that which satisfies (10) exactly.

Expressing the base in terms of the export level associated with the export level associated with the highest subsidy rate, \( X(s_1) \), condition (10) can be solved to yield the critical value of \( \lambda \), which in the linear case reduces to
\[ \lambda^* = \left[ \frac{1}{2} \sum_{k=1}^{1-1} \frac{s_k \Delta_k / s_{k-1}}{\Delta_k / s_{k-1}} \right]^{1/2} - \frac{1}{2} \sum_{k=1}^{1-1} \frac{s_k \Delta_k / s_{k-1}}{\Delta_k / s_{k-1}} \]  

(11)

To obtain the values of \( \delta X_0 \) for which the critical base is such that the maximum profitable export level is equal to \( B_t + \sum_{k=1}^{1-1} \Delta_k \), we now substitute the solution for \( \lambda^* \) from (11) into (5a) to obtain for the linear case

\[ \frac{1}{2} \sum_{k=1}^{1-1} \frac{s_k \Delta_k / (s_{k-1})}{\Delta_k / (s_{k-1})} < \delta X_0 < \frac{1}{2} \sum_{k=1}^{1-1} \frac{s_k \Delta_k / (s_{k-1})}{\Delta_k / (s_{k-1})} \]  

(12)

This is the range of values of \( \delta X_0 \) for which \( X(s_t) < B_t + \sum_{k=1}^{1-1} \Delta_k \times X(s_{k-1}) \) is the highest profitable export level. As can be seen by comparing equations (12) and (9), with values of \( \delta X_0 \) above that range, the subsidy rate effective at the margin of the critical base will be some \( s < s_t \).

\( B_t + \sum_{k=1}^{1-1} \Delta_k \) will never then be attained, and the maximum export level will not exceed \( X(s_t) \). On the other hand, with \( \delta X_0 \) below that range, the effective rate will be \( s \geq s_{k-1} \), and \( B_t + \sum_{k=1}^{1-1} \Delta_k \) will be exported at all bases falling within the range of (5a) for such lower values of \( \delta X_0 \).

This interpretation of equations (9) and (12) may, at first, seem counter-intuitive. To illustrate, suppose that the shaded and hatched areas in Figure 2 are just equal to each other, so that \( B_a \) is the critical base, and exporting \( X(s_{a-1}) \) with the subsidy is no more profitable than exporting \( X_0 \) without it. With the slope of the export supply curve lower, i.e., with a higher \( \delta \), marginal costs at \( B_a \) would also have been lower, with a corresponding reduction in the shaded area (representing the negative profit element) and a corresponding increase in the hatched one (representing the positive one). \( X(s_{a-1}) \) would then be more profitable than \( X_0 \), and the critical base would exceed \( B_a \). But such a case falls, by definition, within the range of (9) for \( i=2 \). On the other hand, \( \delta \) being large enough for the range of (9) to be exceeded, means that the corresponding critical base is
such that the subsidy block starting from it will exhaust its $s_2$ step at some level of exports falling short of $X(s_2)$. Utilizing equations (9) and (12), we calculated the ranges of $\delta X_0$ values resulting in maximum export levels, corresponding to each of the various subsidy rates specified in the EEG Act. These are given in Table 1 with the effective marginal subsidy rate shown in the second column.

**TABLE 1**

Value of the critical base, the highest attainable export increase, and marginal subsidy rate for different ranges of $\delta X_0$

<table>
<thead>
<tr>
<th>$\delta X_0$ ($%$)</th>
<th>Marginal Subsidy Rate (%)</th>
<th>$X^* - X_0$ ($%$)</th>
<th>$B^* - X_0$ ($%$)</th>
<th>$\lambda^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 6.67</td>
<td>15</td>
<td>$\leq 1.0$</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>6.67 - 15</td>
<td>15 or 10(^a)</td>
<td>1.0 - 1.5</td>
<td>0.5 - 1.0</td>
<td>0.5 - 0.444</td>
</tr>
<tr>
<td>15 - 105</td>
<td>10</td>
<td>1.5 - 10.5</td>
<td>1.0 - 5.5</td>
<td>0.444 - 0.349</td>
</tr>
<tr>
<td>105 - 420</td>
<td>10 or 5(^h)</td>
<td>10.5 - 21.0</td>
<td>5.5 - 16.0</td>
<td>0.349 - 0.254</td>
</tr>
<tr>
<td>420 - 620</td>
<td>5</td>
<td>21.0 - 31.0</td>
<td>16.0 - 21.0</td>
<td>0.254 - 0.226</td>
</tr>
<tr>
<td>620 - 2480</td>
<td>5 or 2.5(^a)</td>
<td>31.0 - 62.0</td>
<td>21.0 - 52.0</td>
<td>0.226 - 0.140</td>
</tr>
<tr>
<td>&lt; 2480</td>
<td>2.5</td>
<td>$\geq 62.0$</td>
<td>$\geq 52.0$</td>
<td>$\leq 0.140$</td>
</tr>
</tbody>
</table>

\( \theta \) = export supply elasticity  
\( X_0 \) = pre-subsidy exports  
\( X^* \) = highest profitable exports  
\( B^* \) = critical base  
\( \lambda^* = (B^* - X_0)/(X(s_1) - X_0), \) see text

\(^a\) Supplied curve intersects subsidy block in a vertical segment. The higher marginal subsidy rate applies to decreases in exports, and the lower to increases.

The highest profitable export level, \( X^* \), and the critical base giving rise to it, \( B^* \), are shown in columns 3 and 4 by their respective differences.

---

7. When the subsidy rate corresponding to the maximum export levels falls in between two of the rates specified in the scheme, the higher rate is paid, in effect, at the margin.
from $X_0$, the pre-subsidy level of exports. This is because expressions (7) and (10) are written in terms of the product of $\theta$ and $X_0$ — the quantity which determines the highest export and subsidy level and, as shown subsequently, also the shape of the export cycle, is $S X_0$.

IV. THE CYCLICAL PATTERNS

Under the EKG scheme, the subsidy is paid on the excess of export sales revenues in a given year over their arithmetic average in the three preceding years. Abstracting from changes over time in the world market price (and setting the latter equal to 1 for convenience), the base for year $t$ can be expressed in terms of export levels.

$$B_t = \frac{1}{3} \sum_{j=1}^{3} X_{t-j}$$

Denoting the excess of exports in a given year over their pre-subsidy level by $x_t = X_t - X_0$, and standardizing, as before, in terms of $x(s_1)$, we obtain

$$\lambda_t = \frac{1}{3} \sum_{j=1}^{3} x_{t-j} / S X_0$$

In the first years of the scheme's operation $\lambda_t$ increases with $t$. It should be pointed out that this happens even if the subsidy rate effective at the base's margin remains unchanged, so that $x_t$ is constant, as long as $x_t > 0$. As we have seen, however, there exists some maximum level of $x^* - X^* + X_0$ such that $x_t > x^*$ is unprofitable compared to $x_t = 0$, i.e., to the foregoing of the subsidy by reverting to the initial export level. This decline in $x_t$ affects the size of the base in the following years. Thus, once $x^*$ has been reached, $\lambda_t$ will start to decline, either immediately or after some time lag. As long as $\lambda_t \geq \lambda^*$, $x_t = 0$. But ultimately $\lambda$ will
be reduced to below its critical level. Once this happens, there will be again some $x_t > 0$ which will be more profitable than $x_t = 0$. Exports will again rise, which in its turn will raise $\lambda$, and the whole process will begin again. Thus, under stationary demand and supply conditions, the subsidy scheme will result in exports following a cyclical pattern, the firm finding it profitable to become eligible for the subsidy by expanding exports over their pre-subsidy level in some years, and to forego it in others.

Had the scheme offered only a single subsidy rate, without any limits on the magnitude of the excess of exports over the base eligible for it, the export increment considered by the firm would have always been equal to $x(s) = X(s) - X_0$, where $s$ is the subsidy rate. As we have shown elsewhere, with the export supply curve linear in the relevant range, the critical value of $\lambda$ would then be independent of $\delta X_0$ and equal to $\lambda^c = \frac{1}{4}$ (Kleiman and Pincus, 1990a). In such a case, which corresponds to the Crawford Committee's recommendations, $3\delta/3t$ would be either 0 or $\pm 1/3$, depending on the pattern in which $x(s)$ and $x = 0$ alternated in preceding years. More concretely, $\lambda$ would be zero in the scheme's first year of operation and $1/3$ in the second one, so that $x_1 = x_2 = x(s)$. It would then rise to $2/3 > \lambda^c$ in the third year and, despite $x_3 = 0$, remain at this level also in the fourth one, so that $x_4 = x_4 = 0$. Thus, a four-year cycle would ensue, with two-year runs of $x(s)$ alternating with two-year ones of $x = 0$. This cycle would be the same for all firms, though its absolute amplitude, i.e., $x(s)$, would vary with the firm's characteristics. As we shall now proceed to show, the same is not true of multi-rate schemes such as the EEC one.

Here, the length of the cycle, its relative amplitude, and the length of its different phases, all depend on $\delta X_0$, and may, therefore, vary from one individual firm to another.
It follows from the step-wise shape of the multi-rate subsidy bloc
that the subsidy rate effective at the margin varies with the position of
the bloc, i.e., with the base, and with the position and shape of the export
supply curve. Equations (3a) and (5a) indicate that the subsidy rate
effective in the scheme’s first year of operation, when \( \lambda = 0 \), will vary
inversely with \( 6X_0 \). As indicated by equations (9) and (12), the same is
true of the rate effective at the margin of the critical base. Thus, a
firm will qualify for an altogether lower range of subsidy rates, the
higher its \( \theta \) and \( X_0 \). And within each such range, the effective subsidy
rate will increase with the base. Therefore, even in the expansion phase
of the cycle, the export increments which the firm will be considering to
come eligible for the subsidy will not be constant, but will vary with
the effective subsidy rate both across firms and over time. It should be
pointed out that these variations in the amplitude of the cycle do not
reflect just the differences in the absolute effect of a given subsidy
rate on firms with different export supply elasticities and different
pre-subsidy export levels, but also those in the subsidy rate offered,
in effect, to different firms and to the same firm at different times.

With the magnitude of the export increment, relative to the pre-
subsidy level, varying from one year to another, the values which \( \lambda \) assumes
do not vary in the simple discrete manner in which, as shown above, they
do when \( x_{t-1} \) is restricted to either some unique \( x(a) \) or zero. Again,
equations (3a) and (5a) show that \( X_0 \) determines the value \( \lambda_{t-1} \) for \( t=2 \)
and, therefore, also for higher values of \( t \), until \( \lambda_{t+1} \). At the same time,
as shown by equations (8) and (11), it also determines the value of \( \lambda^t \).
Consequently, it determines both the duration of the cycle and the length
of its different phases. To illustrate, let us consider two extreme cases.
In the first one \( 0X_0 \leq \Delta_1/s_1 \) which, under the EEG Act amounts to 3.33
million dollars. The effective subsidy rate in this case is \( s_1 \) in all
periods, and the results are identical with those obtained earlier for a single-rate scheme. The export increment considered by the firm is constant at \( a(\lambda) = 1/2X_0 \), equal to half a million dollars, and \( \lambda = \frac{1}{3} \). The firm will find it profitable to benefit from the subsidy in the scheme's first two years, when \( \lambda \leq 1/3 \), and to forego it in the following two ones, when \( \lambda = 2/3 \). This pattern will then repeat itself, with exports fluctuating in a symmetrical four-year cycle, and the subsidy's effect amounting to only one-half of the maximum attainable. On the other hand, with \( \Theta X_0 = \frac{3}{6} \sum_{k=1}^{4} \theta_k \), the subsidy will induce an export increase of \( \theta \delta X_0 = 10 \) in the first year. As can be seen from Table 1, the subsidy rate effective at the margin of the critical base in this case is \( s_2 < s < s_1 \). Solving equation (11) for the corresponding values we obtain \( \lambda = 0.25823 \), so that the maximum export increment profitable, \( \lambda s_2 \delta X_0 + 2\delta X_0 \), is equal to 20.5 million dollars. The successive expansion of exports in this case is summarized in Table 2. As shown there, \( \lambda \) never assumes a value close enough to \( \lambda \) (but falling short of it), which would make this maximum increment profitable to the exporter. The highest export increment ever achieved amounts to 20 million dollars. This will be attained gradually, in an adjustment period lasting four years. Thereafter, a steady-state four-year cycle will be observed, of three years of \( x = 20 \), followed by one year of exports at their pre-subsidy level of \( X_0 \). And the average export increment over the cycle will amount to 15 million dollars, three-quarters of that attainable in any one of the high export years.

The example provided in Table 2 is only one out of a very large number of possible adjustment paths of varying length, and of different steady-state cyclical patterns, which the EER scheme may generate, depending on the value \( \Theta X_0 \). It is impracticable to calculate all of them. To provide some idea of their variety, we provide in Table 3 the absolute values of the subsidy-induced export increment for some arbitrarily selected values of
### TABLE 2

Adjustment Path and Steady-State Cycle of Exports

\[
3 X_0 = \frac{1}{\Delta_k/s} = 400
\]

<table>
<thead>
<tr>
<th>Year (^{(a)})</th>
<th>Excess of base over (X_0)</th>
<th>(\lambda)</th>
<th>Export increment</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>-1</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>3.33...</td>
<td>0.0555...</td>
<td>13.33...</td>
</tr>
<tr>
<td>3</td>
<td>7.77...</td>
<td>0.12963</td>
<td>17.77...</td>
</tr>
<tr>
<td>4</td>
<td>13.703</td>
<td>0.22840</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>17.037</td>
<td>0.28395(^{(b)})</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>12.593</td>
<td>0.20988</td>
<td>20</td>
</tr>
<tr>
<td>7</td>
<td>10.33...</td>
<td>0.2222...</td>
<td>20</td>
</tr>
<tr>
<td>8</td>
<td>10.33...</td>
<td>0.2222...</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>20.67</td>
<td>0.3333...(^{(b)})</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>10.33</td>
<td>0.2222...</td>
<td>20</td>
</tr>
</tbody>
</table>

\(^{(a)}\) With the EEG scheme operating from year one onwards.

\(^{(b)}\) \(\lambda > \lambda^* = 0.25823\), therefore subsidized exports unprofitable.
$6X_0$, over a period of 20 years. The square brackets in each column enclose the first fully completed cycle. It can be seen, firstly, that while in some cases, e.g., that of column (4), the cyclical pattern appears immediately, in others, e.g., those of columns (2), (3) and (5), it emerges only after an initial adjustment process of varying lengths. Secondly, the cycles are of different duration and shape. Thus, in the case of columns (1) and (4), the cycle is a symmetrical four year one, with two years of equally high exports alternating with two years at the pre-subsidy level. In the case of column (6), described earlier in Table 2, the cycle is one of three years, of high exports followed by only one year at the initial level. Finally, as demonstrated by columns (2), (3), (5), and (7), there are also cases of a number of short cycles of differing direction and magnitude, forming together one long cycle. In the case of column (3), for example, the pattern is of three years of increasing exports, followed by two with zero increments, then again three high export years, but at different levels than before, followed by one year of zero exports and then one year of again high ones — altogether an eleven (sic!) years 'long cycle'. In the case of column (7), this long cycle is of 13 years duration! While in some cases the export level in the high export years will be either constant or increase monotonically, in others, e.g., column (2) and (5), it is quite irregular, the export increment decreasing from one sub-cycle to another, or even within the same one.

This may, at first, seem surprising in view of the step-function nature of the subsidy bloc under the EEC scheme. But, as pointed out earlier, the export increments, and the bases they generate, combine magnitudes which are proportionate to $6X_0$, through a given $s_1$, with absolute ones, determined by the limits imposed by the scheme on the length of the various subsidy steps, the $\delta_1$. This accounts not only for the irregularity of the convergence process, but also for the fact that the steady-state value
TABLE 3

The export increment, \( x_t \), for selected values of \( 0X_0 \) (millions of \$)

<table>
<thead>
<tr>
<th>Year</th>
<th>( 0X_0 )</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>6.0</td>
<td>7.0</td>
<td>12.0</td>
<td>35.0</td>
<td>100.0</td>
<td>400.0</td>
<td>1500.0</td>
</tr>
<tr>
<td>1</td>
<td>0.60</td>
<td>0.60</td>
<td>1.20</td>
<td>3.50</td>
<td>5.00</td>
<td>10.00</td>
<td></td>
<td>37.50</td>
</tr>
<tr>
<td>2</td>
<td>0.70</td>
<td>0.73</td>
<td>1.20</td>
<td>3.50</td>
<td>6.67</td>
<td>13.33</td>
<td></td>
<td>37.50</td>
</tr>
<tr>
<td>3</td>
<td>0.90</td>
<td>0.98</td>
<td>1.30</td>
<td>-</td>
<td>8.89</td>
<td>17.78</td>
<td></td>
<td>37.50</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>20.00</td>
<td></td>
<td>47.50</td>
</tr>
<tr>
<td>5</td>
<td>-</td>
<td>-</td>
<td>1.33</td>
<td>3.50</td>
<td>10.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.80</td>
<td>0.83</td>
<td>-</td>
<td>3.50</td>
<td>-</td>
<td>20.00</td>
<td></td>
<td>38.33</td>
</tr>
<tr>
<td>7</td>
<td>0.77</td>
<td>0.78</td>
<td>1.20</td>
<td>-</td>
<td>8.33</td>
<td>20.00</td>
<td></td>
<td>38.61</td>
</tr>
<tr>
<td>8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>20.00</td>
<td></td>
<td>32.50</td>
</tr>
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<td>-</td>
<td>-</td>
<td>1.20</td>
<td>3.50</td>
<td>7.78</td>
<td>-</td>
<td></td>
<td>48.15</td>
</tr>
<tr>
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<td>0.76</td>
<td>0.76</td>
<td>1.30</td>
<td>3.50</td>
<td>-</td>
<td>20.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>0.75</td>
<td>0.75</td>
<td>1.33</td>
<td>-</td>
<td>7.59</td>
<td>20.00</td>
<td></td>
<td>38.55</td>
</tr>
<tr>
<td>12</td>
<td>-</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
<td>10.00</td>
<td>20.00</td>
<td></td>
<td>38.90</td>
</tr>
<tr>
<td>13</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.50</td>
<td>-</td>
<td>-</td>
<td></td>
<td>37.50</td>
</tr>
<tr>
<td>14</td>
<td>0.75</td>
<td>-</td>
<td>1.20</td>
<td>3.50</td>
<td>-</td>
<td>20.00</td>
<td></td>
<td></td>
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<tr>
<td>15</td>
<td>0.75</td>
<td>0.83</td>
<td>1.20</td>
<td>-</td>
<td>8.33</td>
<td>20.00</td>
<td></td>
<td>37.50</td>
</tr>
<tr>
<td>16</td>
<td>-</td>
<td>0.78</td>
<td>1.33</td>
<td>-</td>
<td>7.78</td>
<td>20.00</td>
<td></td>
<td>37.50</td>
</tr>
<tr>
<td>17</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.50</td>
<td>-</td>
<td>-</td>
<td></td>
<td>37.50</td>
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<tr>
<td>18</td>
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<td>-</td>
<td>1.33</td>
<td>3.50</td>
<td>-</td>
<td>20.00</td>
<td></td>
<td>47.50</td>
</tr>
<tr>
<td>19</td>
<td>0.75</td>
<td>0.76</td>
<td>-</td>
<td>-</td>
<td>7.59</td>
<td>20.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>-</td>
<td>0.75</td>
<td>1.20</td>
<td>-</td>
<td>7.53</td>
<td>20.00</td>
<td></td>
<td>38.33</td>
</tr>
</tbody>
</table>

See appendix for derivation
of the export increment does not increase monotonically with \( 0X_0 \) in either relative or absolute terms.

The values of \( 0X_0 \) for which Table 3 was calculated do not represent some selected 'freak cases', or especially exotic ranges. The various cases shown there represent different development patterns in terms of \( \Delta_i \)'s and \( x(\Delta_i) \), as well as the differential effects of the same subsidy rates on firms with different supply elasticities and different initial export levels. As can be seen by comparing column (1) and (2), firms with almost identical characteristics, in terms of \( 0X_0 \), may follow completely different expansion paths. The number of such paths is not proportionate to the width of the relevant \( 0X_0 \) interval. To illustrate, we examined the various combinations in the range \( \Delta_1/2 < 0X_0 < (\Delta_1 + \Delta_2)/2 \), i.e., those where the export supply curve intersects the subsidy bloc in the scheme's first year of operation at the step corresponding to the second highest subsidy rate, \( s_2 \). Under the parameters of the EEG Act, this corresponds to \( 5 < 0X_0 < 50 \), with an initial export increment of between 0.5 and 5.0, million dollars, and a subsidy, at the margin, of 10 per cent.\(^8\)

Despite the uniformity in the scheme's first-year effect, later developments vary both in their time pattern and in the magnitude of the export increments (relative to their pre-subsidy level), with variations in the value of \( 0X_0 \) within the above range. Both the whole \( 15 < 0X_0 < 50 \), and the much narrower 8.6 to 15.0 intervals, follow a single pattern. On the other hand, three different patterns will be observable from the third year onwards in the 5.0 - 7.5 interval, while the 7.5 - 8.6 one will display two different patterns by the seventh year, four by eleventh, and even greater numbers in later years.

---

\(^8\) This is a narrower range of \( 0X_0 \) (though not of the first year's increment) than that in which the firm becomes eligible for a subsidy at this rate in the first year. The latter extends also to all the cases where the supply function intersects the subsidy bloc between the \( s_2 \) and \( s_3 \) steps, i.e. \( 50 < 0X_0 < 100 \).
The first years of the scheme's operation will fulfill the expectations associated with it: during the initial adjustment process, exports will be gradually increasing, in the case of Table 3 in the first two or three, or even four years. This, however, need not be the result of any outward shift in the export supply curve, but simply of movements along it, due to successively higher subsidy rates being in effect offered in successive years of the first expansionary phase. The mechanism through which this expansion will be attained thus differs from the expected one of firms availing themselves of the higher subsidy rates only in the first years. Similarly, the effective subsidy rate may 'taper off' in the convergence process, but not because, as the assumption underlying the scheme would have it, that export supply curves shift out, or become more elastic, with time. Furthermore, insofar as the convergence from the initial expansion phase towards the steady-state level of subsidized exports follows a downhill path, part of the gains made in the early years will turn out to be transitory, with the export increment declining over time. Finally, though the great variety of cyclical patterns generated by the scheme means that their troughs and peaks will not be generally synchronized, years may nevertheless occur in which they will coincide for most of the relevant values of SX, i.e., for most firms, as they do in fact do in Table 3 in the fourth, eighth, and thirteenth years.
V. SUMMARY AND CONCLUSIONS

During the first two years or more, the exports of a firm taking advantage of the EEG scheme will be above the pre-subsidy level, and non-decreasing. Then will follow one or two years at the pre-subsidy export level. The EEG Act has a "sunset" clause limiting grants to annual export increments achieved in the four years starting 1 July 1977. We hypothesize but have not proved that only firms with high values of $X_0$ ($400 m.$ and above in Table 3) will still be obtaining a subsidy in the fourth year, that is, the year in which the questions of renewal or extension of the legislation are raised. Some other firms may have, by then, decided that next year the EEG subsidy would be of no use even if offered. Dissatisfaction with the scheme may then lead to its being scrapped, or modified.

It is the moving-base feature of the EEG scheme which causes export cycles, as also with the Crawford Committee alternative of a tax-free 15 per cent flat-rate marginal subsidy. Clearly, the cyclical pattern could be modified, even eliminated, by inflation or exogenous growth in exports; see Kleiman and Pincus (1980a) for these effects in the context of the Crawford alternative. Although the pattern of export fluctuations under EEG will vary across firms according to variations in $X_0$, it is possible that some significant degree of synchronization could occur, as in Table 3, so that aggregate export might suffer EEG-induced fluctuations. This is despite the fact that, after the initial period of elevated exports, the patterns of export variations can be complex and diverse.

The EEG scheme offers higher export subsidy rates to firms with low values of $X$, that is, to firms with low export supply elasticities, low exports, or both. The negative correlation between subsidy rates achieved

9. It also threatens to run foul of obligations under the codes of the multinational trade negotiations (MTN).
and supply elasticity has elements of economic perversity: the least
couragement is given to firms most capable of cheaply expanding their
exports.\textsuperscript{10} Therefore, a given aggregate export expansion is 'purchased' by
the Treasury at the cost of an aggregate subsidy payment in excess
of the minimum necessary. And yet, the marginal or moving base nature of
the scheme is designed to reduce unnecessary or inframarginal subsidy payments
in an effort to reduce Treasury cost for a given export expansion. Expression
(1) shows that, \textit{cet. par.}, the export elasticity is low when the share of
output going to exports is high. The EEC scheme, then, offers high subsidy
rates to firms already exporting most of the output, that is, to firms in
least need of inducements to consider exporting as a serious alternative to
selling at home! It is likely that these peculiarities were not foreseen.
Firms with low pre-subsidy export levels also, \textit{cet.par.}, enjoy higher rates
of EEC subsidy. Here lies a possible explanation of the political choice of
a regressive subsidy schedule: it reduces the positive correlation between
the size of a firm's initial export, \(X_0\), and the size of the subsidy payment
received. Under a flat marginal subsidy scheme at rate \(s\), the subsidy payment
is \(s^2 X_0\). Unless \(s\) varies inversely in exact proportion to \(X_0\), a flat rate
scheme would involve larger payments to firms with larger initial exports.
If, as well might be the case, larger exporters also have higher export
elasticities, the flat rate subsidy payments would increase disproportionately
with \(X_0\), giving rise to the political criticism that the scheme favours the
already successful (that is, large) exporter. The regressive subsidy scheme,
in contrast, has the possible political advantage that, for a given Treasury

\textsuperscript{10} Here are echoes of the made-to-measure tariff system which selects for
higher tariffs those industries lower down the ranking of comparative
disadvantage.
cost, more firms would take up subsidies assuming, realistically, that there is some threshold of extra profit necessary before a firm alters its export decision in response to government inducements.
APPENDIX

1. From (2) and (3) we have, for $N = 3$

$\frac{1}{3} \sum_{j} X_{t-j} - X_{0}$

(A.1) $\lambda_t = \frac{1}{s_1 \delta X_0}$

Denoting $X_{t-j} - X_{0}$ by $y_{t-j}$, this may be written as

$\frac{1}{3} \sum_{j} y_{t-j}$

(A.2) $\lambda_t = \frac{1}{s_1 \delta X_0}$

2. Substituting (A.2) in (5) and in (10) we obtain that if

(A.3) $s_1 \delta X_0 - \frac{1}{3} \sum_{j} \Delta_k \leq \frac{1}{3} \sum_{j} y_{t-j} \leq s_1 \delta X_0 - \frac{1}{3} \sum_{j} \Delta_k$

then, if

(A.4a) $\frac{1}{3} \sum_{j} y_{t-j} < \frac{1}{2} s_1 \delta X_0 + \sum_{k} \left( \frac{s_k}{s_1} - 1 \right) \Delta_k$

then $y_t = \frac{s_1}{s_k} \delta X_0$

but if

(A.4b) $\frac{1}{3} \sum_{j} y_{t-j} > \frac{1}{2} s_1 \delta X_0 + \sum_{k} \left( \frac{s_k}{s_1} - 1 \right) \Delta_k$

then $y_t = 0$

Similarly, substituting (A.2) in (7) and in (14), we obtain that if

(A.5) $s_1 \delta X_0 - \frac{1}{3} \sum_{j} \Delta_k < \frac{1}{3} \sum_{j} y_{t-j} < s_1 \delta X_0 - \frac{1}{3} \sum_{j} \Delta_k$

then, if

(A.5a) $\frac{1}{3} \sum_{j} y_{t-j} < \left( s_1 \delta X_0 \sum_{k} \left( \frac{s_k}{s_1} \Delta_k \right) \frac{1}{2} - \frac{1}{3} \sum_{j} \Delta_k \right)\frac{1}{2}$

then $y_t = \frac{1}{3} \sum_{j} y_{t-j} + \sum_{k} \Delta_k$.
but if

\[(\Lambda.5b) \quad \frac{1}{3} \sum_{j=1}^{3} y_{t-j} \geq (28x_0) \sum_{k} \lambda_k \lambda_k^{1/2} - \sum_{k} \lambda_k \]

then \( y_\xi = 0 \)
II. Computational procedure

Denote $\Omega_{X_0}$ by $X$

$$\frac{1}{3} \sum_{j=1}^{3} y_{t-j}$$

by $A$

For $t = 0, -1, -2$

$y_t = 0$

For $t \geq 0$

1. \hspace{1cm} 0.15 X - 0.5 \leq A \leq 0.15 X$

if (1a) \hspace{1cm} A < 0.075 X

$y_t = 0.15 X$

(1b) \hspace{1cm} A \geq 0.075 X

$y_t = 0$

2. \hspace{1cm} 0.10 X - 0.5 < A < 0.15 X - 0.5$

if (2a) \hspace{1cm} A < \sqrt{0.15 X} - 0.5

$y_t = A + 0.5$

(2b) \hspace{1cm} A \geq \sqrt{0.15 X} - 0.5

$y_t = 0$

3. \hspace{1cm} 0.10 X - 5.0 \leq A \leq 0.10 X - 0.5$

if (3a) \hspace{1cm} A < 0.050 X + 0.25

$y_t = 0.10 X$

(3b) \hspace{1cm} A \geq 0.050 X + 0.25

$y_t = 0$

4. \hspace{1cm} 0.05 X - 5.0 \leq A < 0.10 X - 5.0$

if (4a) \hspace{1cm} A < \sqrt{1.05 X - 5.0}$

$y_t = A + 5.0$

(4b) \hspace{1cm} A \geq \sqrt{1.05 X - 5.0}$

$y_t = 0$

5. \hspace{1cm} 0.05 X - 10.0 \leq A \leq 0.05 X - 5.0$

if (5a) \hspace{1cm} A < 0.025 X + 5.5

$y_t = 0.05 X$

(5b) \hspace{1cm} A \geq 0.025 X + 5.5

$y_t = 0$
6. \(0.025 X - 10.0 \leq A \leq 0.05 X -10.0\)

\[\begin{align*}
\text{if (6a)} & \quad A < \sqrt{1.55 \times X - 10.0} \\
\text{if (6b)} & \quad A \geq \sqrt{1.55 \times X - 10.0}
\end{align*}\]

\(y_c = A + 10.0\) \quad \(y_c = 0\)

7. \(0 \leq A \leq 0.025 X - 10.0\)

\[\begin{align*}
\text{if (7c)} & \quad A < 0.0125 \times X + 21.0 \\
\text{if (7b)} & \quad A \geq 0.0125 \times X + 21.0
\end{align*}\]

\(y_c = 0.025 \times X\) \quad \(y_c = 0\)
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