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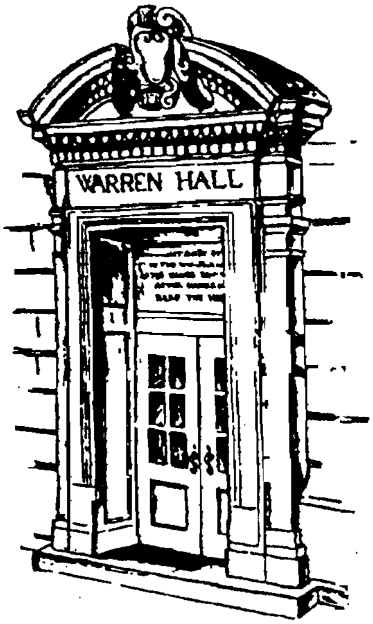

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ENDOGENOUS COMMODITY POLICIES AND THE SOCIAL BENEFITS FROM PUBLIC RESEARCH EXPENDITURES

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Abstract

A burgeoning literature on how the benefits from research may be negative in the presence of price supports depends on at least two critical factors. First, in comparing the social benefits of research with and without commodity policy, these studies (implicitly) assume that *the level of the commodity policy instrument is held constant*. This necessarily implies that the *net transfer to farmers increases*. We show that the reverse (commodity policy changes and net transfers constant) will generate very different results, namely, that the deadweight costs of price supports almost always *declines* with research expenditures. Second, these studies fail to specify the underlying objective function or decision-mechanism of the government in assessing the efficacy of research expenditures in the presence of commodity policy. We specify three alternative objective functions, each having commodity policy endogenous (i.e., adjusting after an exogenous change in the level of cost reducing public research expenditures). We determine that the social benefits from research in the presence of endogenous commodity policy are higher than that determined by studies in the literature that assume an exogenous commodity policy. This has important policy implications.

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1. Introduction

Several papers emphasize the importance of analyzing the welfare economics of public good and commodity policies jointly (see Lichtenberg and Zilberman, and Alston, Edwards and Freebairn for earlier works, and Murphy, Furtan and Schmitz for a more recent contribution). The latter two studies compare the social benefits from cost-reducing public research expenditures under alternative commodity policies with the benefits of research under no commodity policy. Although no general conclusion can be drawn, Alston, Edwards and Freebairn determine that *few*, if any commodity policies (that favor farmers) result in an increase in the social benefits from research. This explains the emphasis by Murphy, Furtan and Schmitz, who go one step further than Alston, Edwards and Freebairn, that the social benefits from research expenditures may be negative in the presence of a commodity policy.

In this paper, we show that the results of studies like that of Alston, Edwards and Freebairn and of Murphy, Furtan and Schmitz depend on at least two critical factors. First, in comparing the social benefits of research with and without commodity policy, these studies (implicitly) assume that *the level of the commodity policy instrument is held constant*. This necessarily implies that the *net transfer to farmers increases*. We show that the reverse (commodity policy changes and net transfers constant) will generate very different results, namely, that the deadweight costs of price supports almost always *declines* with research expenditures. We conclude that both approaches are equally arbitrary.

Second, these studies fail to specify the underlying objective function or decision-mechanism of the government in assessing the efficacy of research expenditures in the presence of commodity policy. Anania and McCalla show that a social welfare maximizing government will have no commodity policy unless there are favorable international terms of trade effects. A framework of analysis is needed that has a government objective function which predicts the existence of alternative commodity policies in the first place. To this end, we specify three alternative objective functions, each having commodity policy endogenous (i.e., adjusting after an exogenous change in the level of cost reducing public research expenditures). We determine that the social benefits from research in the presence of endogenous commodity policy are higher than that determined by studies in the literature that assume an exogenous commodity policy. This has important policy implications.

Our analysis maintains the assumptions of the cited literature that research is exogenous and induces a shift in the supply curve. In addition to the effect on national welfare, we determine the distributional effects (while ignoring the effects on other countries). As in these other studies, we also assume that the choice of the policy instrument is exogenous, i.e., that the specific commodity policy under consideration is assumed to be the only available instrument to redistribute income. We analyze the impact of research on deadweight costs for several stylized policy-trade combinations and government decision-making formulations. The policy-trade combinations include a production quota for a non-traded good, a target price with deficiency payment for a non-traded good, an import tariff for a small country, and a fixed price support with export subsidies for a large country.

The distinguishing feature of our analysis is that we have an endogenous level of the commodity policy, using alternative government objective functions with each predicting commodity policy in all cases. The equilibrium commodity policy, however, adjusts following the introduction of the cost-reducing research, thereby augmenting the aggregate effect of commodity policy on the benefits from research. The extent of adjustment in commodity policy depends on both the specific policy instrument under consideration and the assumed objective function of the government.

This paper is organized as follows. The following section outlines a general model. In section 3, we compare the social benefits of research under the assumption (eg, Alston, Edwards and Freebairn) of a *fixed policy instrument level* (for several commodity policies) with those under an equally arbitrary assumption of a *fixed net transfer level*. In every case, the Alston, Edwards and Freebairn methodology yields smaller social benefits from research in the presence of commodity policy.

In section 4, we analyze two stylized commodity policies under three alternative government objective functions: (a) maximize income subject to a farm income constraint; (b) maximize a weighted preference function; and (c) maximize political support. The social benefits from research in the presence of a commodity policy are found to be mostly higher than that of the literature which assumes commodity policy instrument levels to be fixed. The final section provides some concluding remarks as to the policy implications vis-a-vis the received wisdom of the literature analyzing the welfare economics of research and commodity policy.

A General Model

Define e^i as the net income of individual i prior to the introduction of research and commodity policy. Consider now the introduction of a commodity policy that redistributes income between sectors. Define $t^i(t)$ as the net aggregate income transfer for i resulting from the commodity policy. Define y^A as the income of agricultural producers, which can be decomposed into income from market activities (e^A) and income transfers from the commodity policy (t^A):

[1] $$y^A = e^A + t^A$$

Define y^B as the income of consumers and taxpayers:[1]

[2] $$y^B = e^B + t^B$$

Typical commodity policies like price supports, import tariffs, export subsidies and production quotas induce deadweight costs. Define $t^i(0) = 0$, $t^A(t) = t$ and $t^B(t) = - t - c(t)$, where c(t) represents the deadweight costs. Therefore, $t > 0$ describes the aggregate net income transfer *to* farmers, with agriculture subsidized by consumers and/or taxpayers.

How are the benefits from research affected under these market distortions induced by commodity policy? The total effect of research on national income is given by:

[3] $$dY/d\tau = de^A/d\tau + de^B/d\tau - dc/d\tau - 1$$

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[1] For simplicity, we combine consumers and taxpayers into one group.

Equation [3] indicates that the impact of research on total income is the sum of the change in market incomes ($de^i/d\tau$) from both producers and consumers (through improved productivity and lower costs/prices), minus the change in total deadweight costs ($dc/d\tau$) and the costs of financing the investment (reflected in the last term, which ignores the excess burden of taxation).

The social optimal research expenditure level τ^m maximizes total national income Y in the absence of commodity policy and is determined by:

$$[4] \qquad de^A(\tau^m)/d\tau + de^B(\tau^m)/d\tau = 1$$

A comparison of conditions [3] and [4] indicates that $dc/d\tau$ is critical in determining how much total income will diverge from maximum income due to commodity policy. Alston, Edwards and Freebairn's analysis, for example, indicates that the net impact of research on deadweight costs is indeterminant, depending on the specific policy and the significance/status of the sector in world markets. However, the latter study indicates that in most cases cost-reducing research increases deadweight costs of commodity policy distortions ($dc/d\tau > 0$), which lowers the aggregate social benefits from research.[2]

Taking Alston, Edwards and Freebairn as an example, the literature compares the benefits from cost-reducing research in the presence of different commodity policies with the benefits from research under free-market conditions. In our notation, this is the difference between $\Delta Y/\Delta\tau$ at a given commodity policy level and $\Delta Y/\Delta\tau$ without commodity policy. Let x represent the level of a given commodity policy instrument. Then the standard basis of comparison can be written as $\Delta Y(x)/\Delta\tau$ - $\Delta Y(0)/\Delta\tau$, and is given by:

$$[5] \qquad \Delta Y(x)/\Delta\tau - \Delta Y(0)/\Delta\tau$$
$$= [\Delta e^A(x)/\Delta\tau + \Delta e^B(x)/\Delta\tau - \Delta c(x)/\Delta\tau - 1] - [\Delta e^A(0)/\Delta\tau + \Delta e^B(0)/\Delta\tau - \Delta c(0)/\Delta\tau - 1]$$
$$= - \Delta c(x)/\Delta\tau$$

[2] In their table 1, Alston, Edwards and Freebairn summarize 13 policy/trade status combinations, of which 7 yield a negative impact, 3 a zero impact, 1 a positive impact and two depending on other factors.

At the margin, it holds in general that $dY(x)/d\tau - dY(0)/d\tau = - dc(x)/d\tau$.[3]

We can disaggregate the total impact of public research τ on deadweight costs of the commodity policy ($dc/d\tau$):

$$[6] \qquad dc/d\tau = \partial c/\partial\tau + (\partial c/\partial t)(\partial t^*/\partial\tau)$$

where the first term, $\partial c/\partial\tau$, represents the impact of τ on c *for a given level of the net income transfer t.* The second term $\partial c/\partial t$ reflects the change in deadweight costs if there is a change in the net income transfer t. The optimal transfer t* can be solved from a specific government objective function, which also determines the magnitude of the final term $\partial t^*/\partial\tau$, reflecting the extent to which the optimal transfer t* changes with public research.

For example, Alston, Edwards and Freebairn's analysis assumes that the level of the commodity policy x is held constant as public research investments increase. Therefore, they (implicitly) assume that the government increases the transfer to agriculture at the same time when they invest (more) in research, i.e. $\partial t^*/\partial\tau > 0$ in their analysis.[4] As such, t* is implicitly endogenous in their model, because t* adjusts with an increase in τ.

To illustrate the importance of any underlying assumption, let us consider the (equally arbitrary) assumption that the net transfer to farmers is held constant (i.e. $\partial t^*/\partial\tau = 0$) for four stylized commodity policies.

Output quota (closed economy)

Figure 1 depicts the case of an output quota in a closed economy, where D and S(0) represent the demand and supply curves, respectively. Denote Q_a as the initial output quota, generating a new price p_a. The net income transfer t* is area ABDE - DFG. Research shifts the supply curve to $S(\tau)$, causing deadweight costs to increase from area BFG to area BIH. This

[3] This result is also shown in Alston and Martin, and Anania and McCalla. Murphy, Furtan and Schmitz push the argument further and claim that research investments may increase deadweight costs of commodity policy to the extent that "gross annual research benefits (GARB)" are negative. In our notation, Murphy, Furtan and Schmitz show that $\Delta e^A(x)/\Delta\tau + \Delta e^B(x)/\Delta\tau < \Delta c(x)/\Delta\tau$ for a typical commodity policy.

[4] The same applies to Murphy, Furtan and Schmitz.

confirms the conclusion by Alston, Edwards and Freebairn that deadweight costs increase with research ($dc/d\tau > 0$) for a given level of the commodity policy instrument.

Now consider the case where the net transfer t* is held constant . The government needs to increase the output quota to Q_b . The resulting price is p_b and t* equals area RLNJ - NIM = ABDE - DFG (by construction). It follows that $dc/d\tau < 0$. To show this, consider the case where $p_b - p_\tau = p_a - p_0$, which would imply that $dc/d\tau = 0$. In this case NIM = DFG (with linear supply and demand curves), while RLNJ > ABDE. This would imply that $\partial t^*/\partial \tau > 0$, which is inconsistent with our initial assumption. Therefore, it must be that $p_b - p_\tau < p_a - p_0$ which implies that LIM < BFG, and so $dc/d\tau < 0$.

Target price and deficiency payments (closed economy)

Figure 2 depicts a target price T_0 to producers and a market clearing price p_0 paid by consumers. The net transfer to farmers is area HIBA and the increase in consumer surplus is area ABJK. Taxpayer expenditures are area HIJK and social costs are area BIJ. Now consider the effects of public research expenditures that shifts the supply curve to $S(\tau)$. With a fixed target price, deadweight costs *increase* to CLM and market prices fall to p_1. However, if the transfer t* is to be held at the initial level (= HIBA), then the target price is reduced to T_1 and consumer prices rise to p_2. Social costs <u>decrease</u> from BIJ to CRT, with t* = URCV = HIBA.

Import tariff (small country)

Figure 3 shows the impact of research with an import tariff for a small country. Farmers receive T_0 above the world market price p_0, sustained by an import tariff $T_0 - p_0$. Domestic consumption is $Q^d(0)$ and supply is at $Q^S(0)$. The net transfer to farmers induced by the import tariff is area ABED with deadweight costs associated of areas BIE and NKM.

The public research investment would induce an increase in the transfer t if the import tariff is maintained at $T_0 - p_0$. But in order to keep the transfer t constant, the import tariff has to decline to $T_1 - p_0$. Domestic prices fall from T_0 to T_1. Consumption and production both increase, to $Q^d(\tau)$ and $Q^S(\tau)$, respectively. Deadweight costs $c(\tau)$ equal the sum of areas FJH and RLM. It is evident from Figure 3 that $c(\tau) < c(0)$: hence $\Delta c/\Delta\tau < 0$. In the appendix, we show formally that $\partial c/\partial t > 0$,

$\partial c/\partial\tau < 0$, $\partial^2 c/\partial\tau^2 > 0$, and that $\partial^2 c/\partial\tau\partial t$ <,=,> for t > = < 0 in this case of an import tariff for a small country.

Export subsidy with a fixed support price (large economy)

The free market equilibrium before and after the introduction of public research expenditures for a large country exporter is depicted in Figure 4a. The shift in domestic supply also shifts the excess supply curve along the excess demand curve ED facing the exporter, resulting in a new world price equilibrium p_τ. Exports increase to $X(\tau)$ and consumer surplus increases to ABCD. The change in producers surplus is area IHFG minus area AEID. Whether consumers or producers benefit more from research investment τ in the absence of market intervention depends on trade levels and on the supply and demand elasticities.[5]

Consider a fixed support price T_0 with a (variable) export subsidy $T_0 - p_1$ in Figure 4b. Production increases from Q(0) to Q(t) and exports increase from X(0) to X(t). The world market price falls to p_1. Per unit export subsidies equal $T_0 - p_1$. Total taxpayer expenditures equal area JKLM = RSTV. The net transfer to agriculture is the area ASEZ and the change in consumer surplus is - ARBZ.

Deadweight costs c now includes domestic consumption and production distortions (areas RXB and SEW, respectively, with RXB + SEW = KNO) and subsidies to foreign consumers, (equal to area YOLM = XWTV).

With T_0 fixed, deadweight costs increase with research investment τ. However, when t is held constant, T_0 needs to decline. The impact on deadweight costs is less than what it was when T_0 was held constant. Whether deadweight costs increase or decrease depends on several factors, most importantly on the elasticity of domestic and foreign demand, and of domestic supply.

[5] Using the same notation as in the mathematical derivations of the appendix, it follows that without commodity policy, producer surplus $PS = (p^w - p^m)^2/2\alpha$ and consumer surplus $CS = (p^x - p^w)^2/2\pi$. Therefore, $dPS/d\tau = \delta Q^s[(1/\pi)+(1/\gamma)]/\Omega$ and $dCS/d\tau = \delta Q^d/\alpha\Omega$. This implies that producers gain less than consumers from an increase in public research; i.e. $dPS/d\tau < dCS/d\tau$ iff $Q^d/Q^s > \alpha[(1/\pi) + (1/\gamma)]$. This is more likely to occur when the self-sufficiency ratio is greater, when domestic and foreign demand are less elastic (i.e. smaller π and γ) and when supply is more elastic (larger α). These conditions are characteristic of agriculture in industrial countries.

Appendix I shows that $\partial c/\partial\tau$ can only be positive if the export subsidy is small, foreign and domestic demand are inelastic, and if supply is elastic.

Table 1 summarizes the four examples described above. In all cases, $dc/d\tau$ is less when the transfer is held constant ($\partial t^*/\partial\tau = 0$) compared to when the commodity policy instrument level is fixed. Moreover, with the exception of a variable export subsidy scheme in limited circumstances, all cases have deadweight costs declining with research (i.e. $\partial c/\partial\tau < 0$), which implies that $dc/d\tau < 0$ for $\partial t^*/\partial\tau = 0$. This also implies that total income increases with research (i.e., $dY/d\tau > 0$ for $0 < \tau \leq \tau^m$).[6]

Clearly, the impact of research on deadweight costs depends critically on the assumptions regarding the determination of the observed (optimal) level of the net farm income transfer t*, and hence of the commodity policy instrument level x. The analysis above compares two arbitrary rules for determining $\partial t^*/\partial\tau$: fix either the net farm income transfer or the level of the commodity policy instrument. It is more appropriate to specify a particular policy objective function to determine precisely what aspect of redistributive policy is endogenous in order to appropriately evaluate the implications of commodity policy on social benefits to research. We do so in the following section for three alternative decision-mechanisms.

4. Endogenous Commodity Policy under Three Government Decision Models

Maximize Income Subject to a Farm Income Constraint

A government maximizing aggregate social income subject to a farm income constraint is depicted by the following decision problem:

$$[6] \quad \begin{aligned} &\text{Max } Y = y^A + y^B \\ &\text{s.t. } y^A \geq y^o \end{aligned}$$

Assume $e^A < y^o$ such that t* is positive. It follows that $y^A(t^*) = y^o$, with $t^* = y^o - e^A$. What determines the magnitude of $\partial t^*/\partial\tau$ (and consequently $dc/d\tau$) under this model formulation? It will depend on how research affects endowment incomes for producers and consumers (e^A and

[6] This means the "no-gains-from-research-point" in Murphy, Furtan and Schmitz does not exist.

e^B) with no commodity policy. Research reduces consumer prices (unless it is a small country) so $y^B(\tau) \geq y^B(o)$. It follows that $\partial t^*/\partial\tau <$ for $\partial e^A/\partial\tau > 0$ (and vice versa). More specifically, $\partial t^*/\partial\tau = -\partial e^A/\partial\tau$. If research increases e^A to the extent that $e^A(\tau) > y^o$, then t^* will become zero. The critical factor in this model is the impact of τ on e^A, which depends on the structure of the sector (de Gorter and Zilberman) and the commodity policy instrument.

Consider first the case of a small country importer with an import tariff (Figure 3). Producer surplus increases with research ($\partial e^A/\partial\tau > 0$). Hence $\partial t^*/\partial\tau < 0$. Tariffs fall to $T_2 - p_0$. As a consequence, deadweight costs fall to areas HUV + WYM < BIE + NMK. Although the new tariff depicted in Figure 3 is still positive, it need not be so. It depends on the productivity of research, the initial size of the tariff, the trade situation and the supply/demand elasticities.

In the case of a closed economy, equilibrium prices will decline with an increase in research. Consider the case of a *target price with deficiency payments*. Without the target price, the gross gain to consumers is area ABCV and for producers, area FECG minus area ABEV (see Figure 2). It follows that $\Delta e^B/\Delta\tau$ = ABCV and that $\Delta e^A/\Delta\tau$ = (FECG - ABEV). The relative size of the gross benefits depends on the demand and supply elasticities. In the appendix, we formally derive that with demand more elastic than supply ($\pi < \alpha$), benefits for consumers will be smaller than for producers ($de^A/d\tau > de^B/d\tau \iff \alpha > \beta$), and vice versa.

Can $\partial t^*/\partial\tau$ be positive in this scenario? Price reductions will be larger with a more inelastic demand and a more elastic supply. This will have a more adverse effect on producer surplus. Figure 5 shows how, with perfectly inelastic demand (D_1), the induced equilibrium price change equals the vertical shift of the supply curve (i.e. the reduction in marginal costs induced by research). Producer income e^A changes from area ABD to area EFG with research. By construction, ABD = EFG and therefore $de^A/d\tau = 0$. With demand less than perfectly inelastic (D_2), e^A shifts from ABD to HIG. As HIG = HIFE + EGF < EGF = ABD, it follows that $de^A/d\tau > 0$.

Therefore, we can conclude that under this decision model that $\partial t^*/\partial\tau \leq 0$ *always* (with $\partial t^*/\partial\tau < 0$ unless demand is perfectly inelastic). As a consequence $dc/d\tau < \partial c/\partial\tau$, and the aggregate impact of research on deadweight costs is even more negative under this decision-model than when $\partial t^*/\partial\tau = 0$ in our earlier analysis.

Government Maximizing a Weighted Income Preference Function

A government maximizing a weighted income preference function is given by:

[7] $\quad \text{Max} \quad \theta y^A + y^B$

where $\theta \geq 0$ is the relative weight farm incomes have in the government's objective function. The optimal transfer for this government is determined by

[8] $\quad dc(t^*)/dt = \theta - 1$

which implies that $t^* > 0$ for $\theta > 1$: commodity policy favors farmers if they have a higher weight than consumers.

How will τ affect the optimal transfer t^* under this decision problem? Applying the implicit function theorem to [8], one can derive:

[9] $\quad \partial t^*/\partial\tau \; = \; -(\partial^2 c/\partial t\partial\tau)/(\partial^2 c/\partial t^2).$

Condition [9] indicates that t^* will increase if research induces *marginal* deadweight costs to decrease for a given transfer, provided that the deadweight cost function is convex (i.e. $\partial^2 c/\partial t^2 > 0$). The change in optimal transfer only depends on the deadweight cost function. If research makes it less (more) expensive at the margin to redistribute income, the government will increase (reduce) the transfer. The effect of τ on marginal deadweight costs will, again, depend on the particular commodity policy instrument.

In the appendix, we show that $\partial^2 c/\partial t\partial\tau < 0$ and $\partial^2 c/\partial t^2 > 0$ for *an import tariff ($t > 0$) in a small country*. Using condition [9], this implies that the optimal transfer t^* increases with research expenditures τ ($\partial t^*/\partial\tau > 0$). Therefore, $dc/d\tau > \partial c/\partial\tau$, with $\partial c/\partial\tau < 0$ as shown before. Can the increase in deadweight costs induced by the optimal transfer t^* be more than offset by the reduction in the deadweight costs per unit of transfer, i.e. can $(\partial c/\partial t)(\partial t^*/\partial\tau) + \partial c/\partial\tau > 0$ despite $\partial c/\partial\tau < 0$?

In the appendix, we derive the following condition: $\partial c/\partial t = (1+(\alpha/\pi))\,(p^t - p^w)/(p^t - p^m)$, where α and π are the slopes of the linear supply and demand functions, p^w is the world market price, p^t the domestic price and p^m the intercept of the supply function with the vertical axis. Condition [8] for the case of a tariff in a small country becomes:

[10] $(p^t - p^w)/(p^t - p^m) = (\theta - 1)(1+(\alpha/\pi))$

Given our assumptions, all parameters on the right hand side of condition [10] are unaffected by τ. Hence, for $p^t > p^w > p^m$, it must be that $0 < (\theta - 1)\,(1 +\alpha/\beta)\,) < 1$, which in turn implies that $\partial p^t/\partial p^m < 0$. As τ induces a decline in p^m, this means that p^t will increase, inducing an increase in deadweight costs c(t): $dc/dt > 0$.

Notice that, for a similar reason, $\partial c/\partial\tau < 0$ and $\partial t^*/\partial\tau > 0$ because there is a reduction in total ($\partial c/\partial\tau$) or marginal ($\partial^2 c/\partial t\partial\tau$) deadweight costs per unit of transfer. In this case, the term $\partial t^*/\partial\tau > 0$ more than offsets the term $\partial c/\partial\tau < 0$.

In case of a *target price with deficiency payments in a closed economy*, $\partial^2 c/\partial t\partial\tau < 0$ and the sign of $\partial^2 c/\partial t^2$ is conditional on the elasticity of demand and supply. With demand more elastic than supply ($\alpha > \beta$), the deadweight cost function is convex ($\partial^2 c/\partial t^2 > 0$) (and vice versa if supply is more elastic than demand). This implies that the transfer t* will decline when supply is more elastic than demand. In this case, the total effect of τ on deadweight costs is unconditionally negative: $dc/d\tau < 0$ for $\alpha < \beta$, with $\partial c/\partial\tau < 0$, $\partial c/\partial t > 0$, and $\partial t^*/\partial\tau < 0$. When supply is less elastic than demand and the deadweight cost function is concave, $\partial t^*/\partial\tau$ is positive. The impact on $dc/d\tau$ is then conditional on other factors.

Maximizing Political Support

Now consider the case when the government maximizes political support (de Gorter and Tsur). Following Swinnen and de Gorter (1993) and Swinnen (1994), assume that the government solves the following specific problem:

[11] $\max\ S^A(t) + S^B(t)$

subject to the government budget constraint, where S^i is political support provided by the agents in the economy, which has the following form:

$$[12] \quad S^i = S^i[U^i(t,\tau) - U^i(0,0)]$$

The functions $S^i(.)$, $U^i(.)$, and therefore $V^i(.)$, are continuous, at least twice continuously differentiable, strictly increasing and strictly concave. Assume that both sectors pay equal shares of the research expenditures, and that there are no distortions caused by the taxes in financing these investments. Hence:

$$[13] \quad y^i = e^i + t^i - \tau/2$$

The first order condition for the politically optimal level of the net farm income transfer t* for a given level of the public investment, financed by tax $\tau°$, is given by:

$$[14] \quad S^i_V(t^*,\tau°)U^i_y(t^*,\tau°) \; - \; S^i_V(t^*,\tau°)U^i_y(t^*,\tau°)\,(1+dc(t^*,\tau°)/dt) \; = 0$$

where S^i_V and U^i_y are first order derivatives with respect to their respective arguments. The size and sign of t* depends on (a) the deadweight costs associated with the commodity policy, (b) the relative pre-policy endowment incomes between agriculture and industry, and (c) the distributional impact of the public investment (Swinnen and de Gorter, 1995).

How is the optimal transfer t* affected by research when the government maximizes political support? From [14], we can derive:

$$[15] \quad \frac{\partial t^*}{\partial \tau} = - \frac{w^A \, y^A_t - w^B \, y^B_\tau - z^B c_{t\tau}}{w^A \; + w^B \, (1 + c_\tau)^2 + z^B c_{tt}}$$

where $w^i = S_{VV}{}^i(U_y{}^i)^2 + S_V{}^i \, U_{yy}{}^i$ and $z^i = S_V{}^i \, U_y{}^i$. Concavity of S^i and U^i imply that $w^i < 0$ and $z^i > 0$.

In this case of government maximizing political support, the effects on marginal deadweight costs are still operative, as discussed in the previous decision formulations, but there will be an additional and more important consideration. This can be seen by comparing equations

[9] and [15]. The last terms in both the numerator and denominator of [15] correspond to the numerator and denominator of [9]. However these terms are now only partial effects, weighted by the z^i and w^i terms. The other terms in [15] reflect the "political interaction effects (PIEs)" (Swinnen and de Gorter, 1995). This means that research investment τ will affect the marginal political support levels for a given transfer level t, and as a consequence, τ will affect the politically optimal t*.

Let us discuss condition [15] in detail, for the case of a small country import tariff. First, $c_{tt} > 0$, which implies that the denominator is always negative. The sign of the numerator depends on $y^A{}_\tau$ and $y^B{}_\tau$. First, define τ^i as the optimal research level for sector i, which is determined as $y^i{}_\tau(\tau^i) = 0$. A support maximising government will never implement an investment level outside the interval $[\tau^A, \tau^B]$, because both sectors will support shifting the investment level inside this interval. Furthermore, for every τ within this interval, it must be that $y^A{}_\tau$ and $y^B{}_\tau$ have opposite signs (unless one is zero).

Recall that $y^A{}_\tau = e^A{}_\tau - (1/2)$ and $y^B{}_\tau = e^B{}_\tau - (1/2) - c_\tau$. In the case of a small country import tariff, $e^A{}_\tau > 0$, $e^B{}_\tau = 0$ and $\partial c/\partial\tau < 0$. This implies that all the research benefits in the absence of commodity policy go to farmers. Consider what would happen with t*. In the absence of market distortions, $c_\tau = 0$, $c_{t\tau} = 0$, $y^A{}_\tau > 0$ and $y^B{}_\tau < 0$ which would imply that the first and second term in condition [15]'s denominator are negative and the third term zero, and thus that $\partial t^*/\partial\tau < 0$. In general, it is politically optimal for the government to compensate the sector which benefits relatively less from the investment by raising the transfer to this sector. In this case, agriculture benefits more from the investment ($e^A{}_\tau > e^B{}_\tau = 0$) and so the transfer t* decreases. The political interaction effect induces a decline in the transfer t* (and thus of the commodity policy instrument level).

This result is mitigated because (a) deadweight costs per unit of transfer decline with τ ($c_\tau < 0$) and (b) marginal deadweight costs per unit of transfer decrease ($c_{t\tau} < 0$). It cannot be ruled out that these "economic interaction effect (EIEs)" can under certain circumstances more than offset the "political interaction effects (PIE)". The latter ($c_{t\tau} < 0$) makes the last term of the numeration of [12] positive. The former ($c_\tau < 0$) increases $y^B{}_\tau$: consumers benefit because the deadweight costs on the existing transfer declines : $y^B_\tau = -c_\tau - (1/2)$. With $y^A_\tau = e^A_\tau - (1/2)$, $y^A_\tau > y^B_\tau$ requires that $e^A_\tau > -c_\tau$.[7]

Simulations indicate that, while the (secondary) EIEs mitigate the (primary) PIEs, they do not offset them, except under extreme assumptions on the parameters (Swinnen and de Gorter, 1995). Therefore, the simulations suggest that, in general, $\partial t^*/\partial\tau < 0$ will result in this case, implying that $dc/d\tau < 0$. In summary, we emphasize that the same factor which reduces the impact of τ on deadweight costs c ($\partial c/\partial\tau < 0$), causes c to increase, because it induces an increase in the equilibrium transfer (or reduces it less).[8]

In the case of a *target price and deficiency payment*, the effects also depend on the relative elasticity of supply and demand. When demand is inelastic and supply elastic ($\alpha > \beta$) agriculture benefits more from research than consumers in the absence of market intervention. ($e^A_\tau > e^B_\tau$). This tends to increase the optimal transfer. This effect is mitigated by the negative effect of τ on total and marginal deadweight costs: $c_\tau < 0$ and $c_{t\tau} < 0$. If $e^A_\tau > e^B_\tau - c_\tau$, then the first and second term of the numeration of [15] will be negative. With $c_{t\tau} < 0$, the last term will be positive. If the $e^A_\tau > e^B_\tau$ effect is stronger, then $\partial t^*/\partial\tau < 0$ for $\alpha > \beta$. Combining this with $\partial c/\partial\tau < 0$ yields that $dc/d\tau < 0$ under these conditions. When $\alpha < \beta$, all three terms of the numerator of [15] are positive. However now the third term of the denominator is positive (while the other two are negative) as $c_{tt} < 0$ for $\alpha < \beta$. If the first two terms are stronger, $\partial t^*/\partial\tau > 0$ and the net effect on $dc/d\tau$ is conditional, again.

Summary and Discussion

As summarized in Table 2, in only one case does research unconditionally increase deadweight costs of commodity policy (small country import tariff with government maximizing a

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[7] If research has an insignificant effect on producer surplus (e^A_τ) but a large impact on deadweight costs (c_τ), then it is possible that $y^A_\tau < y^B_\tau$. Specifically, one can show (see appendix) that $e^A_\tau \geq c_\tau \iff 1 + s - (1 + (\alpha/\beta))s^2 \geq 0$ where $s = (p^t - p^w) / (p^w - p^m)$. This is more likely if supply is elastic (α small), if demand is inelastic (β large) and if the tariff level is high (s large). For example with s = 1 (100%), $e^A_\tau \geq c_\tau$ if supply is more elastic than demand ($\alpha \leq \beta$). With s = 0.5 and 0.1, this requirement reduces to $\alpha \leq 5\beta$) and $\alpha \leq 109\beta$, respectively.

[8] This offsetting effect holds in general. In case of very distortionary policies for which $\partial c/\partial\tau > 0$, the EIE impact on $\partial t^*/\partial\tau$ would be negative, inducing a decrease in equilibrium transfers, which would tend to offset the "direct" positive effect of $\partial c/\partial\tau > 0$.

weighted preference function). In three cases, the impact is unconditionally negative: deadweight costs decrease with research. In two more cases, deadweight costs will decrease if PIEs outweigh EIEs in determining $\partial t^*/\partial t$.[9]

In Table 1, the only policy/trade combination that could have of research increasing deadweight costs for a given transfer ($\partial c/\partial \tau > 0$) was export subsidies in a large country with a *fixed price support.* Apart from the fact that no export subsidy program operates this way (loan rates and intervention prices vary in the United States and the European Union, respectively), it is still not likely that deadweight costs increase with fixed support prices. In the appendix, we show that $\partial c/\partial \tau > 0$ may result when the export subsidy is small, when foreign and domestic demand are inelastic, and when domestic supply is elastic. But we also show that under these (elasticity) conditions, agriculture is likely to benefit most from research (see the appendix for a formal derivation). Therefore, research will induce a government (maximizing either social welfare or political support) to reduce the optimal transfer t* to agriculture. This has the opposite effect on deadweight costs and so may offset the $\partial c/\partial \tau$ factor.

Concluding Remarks

There is a burgeoning literature analyzing the welfare economics of public research and commodity policies jointly (for example, see Alston and Martin; Murphy, Furtan and Schmitz). Social benefits from research under alternative commodity policies are compared with the benefits of research under no commodity policy. The consensus is that commodity policies result in a decrease in the social benefits of research, and indeed the latter may go negative. The policy implications are very grave and are best summarized by Murphy, Furtan and Schmitz (p. 162):

> "Why continue investing in agricultural research ... if the major impact is ... additional export subsidies? Are the results from past studies showing impressive returns to research still valid?"

We show in this paper that these results depend on the critical assumption that *the level of the commodity policy instrument is held constant* (necessarily requiring an increase in the *net transfer*

[9] This was the case in all simulations in Swinnen and de Gorter (1995). Notice further that this is a sufficient but not a necessary condition, because $dc/d\tau<0$ might still result with $\partial t^*/\partial \tau > 0$ as long as the $\partial c/\partial \tau$ (< 0) effect is stronger.

to farmers). We show that the reverse (commodity policy changes and net transfers constant) will generate very different results, namely, that the deadweight costs of price supports almost always *decline* with research expenditures. Indeed, in every case, the Alston, Edwards and Freebairn methodology yields smaller social benefits from research in the presence of commodity policy.

We conclude that both approaches are equally arbitrary and to overcome this, one needs to specify the underlying objective function or decision-mechanism of the government in assessing the efficacy of research in the presence of commodity policy. We determine that the social benefits from research in the presence of endogenous commodity policy are higher than that determined by studies in the literature that assume an exogenous commodity policy. This has important policy implications in that governments should be encouraged to continue productive research investments in the presence of commodity policy.

The distinguishing feature of our analysis is that we have an endogenous commodity policy, using alternative government objective functions with each predicting commodity policy in all cases. The equilibrium commodity policy, however, adjusts following the introduction of the cost-reducing research, thereby augmenting the aggregate effect of commodity policy on the benefits from research. We show that the extent of adjustment in commodity policy depends on both the specific policy instrument under consideration and the assumed objective function of the government.

Further research should have both research and commodity policy endogenous (de Gorter, Nielson and Rausser). Nevertheless, our analysis shows the importance of departing from the stringent assumptions of the literature whereby the level of the commodity policy is exogenous and the net income transfer to farmers changes with research.

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Appendix

In this appendix, we analyze the impact of public research expenditures on deadweight costs for three commodity policies. We use a partial equilibrium model with linear functions, as presented in the figures and discussed in the text above.

A.1 Target price with deficiency payments in a closed economy

Define the supply and demand functions as :

[a.1.1] $$Q^s(p) = (p - p^m)/\alpha$$
$$Q^d(p) = (p^x - p)/\pi$$

which are linear by assumption and where p^m and p^x are the intercepts of the inverse supply and demand curves with the vertical axes; and α and π are the absolute values of their slopes. Without government intervention in prices, producer surplus (= e^A) and consumer surplus (= e^B) are :

[a.1.2] $$e^A = (p^w - p^m)^2/2\alpha \quad \text{and} \quad e^B = (p^x - p^w)^2/2\pi ,$$

where p^w is the equilibrium price without government intervention. Using the demand and supply equations, p^w equals:

[a.1.3] $$p^w = [(p^m/\alpha) + (p^x/\pi)] / [(1/\alpha) + (1/\pi)]$$

It follows that

[a.1.4] $$e^A_\tau = \delta\, Q^s(p^w)\, (1/\pi)/[(1/\pi)+(1/\alpha)] \quad \text{and}$$
$$e^B_\tau = \delta\, Q^s(p^w)\, (1/\alpha)/[(1/\pi)+(1/\alpha)]$$

where $\delta = - dp^m/dt$ reflects the productivity of the investment function. Hence, $e^A_\tau > e^B_\tau$ if demand is more elastic than supply ($\alpha > \pi$).

The transfer t (which we define the net aggregate transfer to agriculture) is:

[a.1.5] $$t = t^A = [(p^t - p^m)^2 - (p^w - p^m)^2] / 2\alpha$$

with the deadweight costs c associated with t being:

[a.1.6] $$c(t) = (p^t - p^w)^2 / 2\alpha + (p^w - p^c)^2 / 2\pi$$

We can then analyze the impact of public investment τ on deadweight costs c associated with the transfer t:

[a.1.7] $$\partial c/\partial \tau = [(p^t - p^w)/\alpha]\, [\partial p^t/\partial \tau - \partial p^w/\partial \tau] + [(p^w - p^c)/\pi]\, [\partial p^w/\partial \tau - \partial p^c/\partial \tau]$$

To determine the sign of $\partial c/\partial\tau$, we use the fact that t remains constant :

[a.1.8] $$\partial t/\partial\tau = [(p^t - p^m)/\alpha]\,[\partial p^t/\partial\tau - \partial p^m/\partial\tau] + [(p^w - p^m)/\alpha]\,[\partial p^w/\partial\tau - \partial p^m/\partial\tau] = 0$$

We can derive that

[a.1.9] $$\partial p^w/\partial\tau - \partial p^m/\partial\tau = \delta\,(1/\pi) / [(1/\alpha) + (1/\pi)] > 0,$$

and, using [a.7] and [a.8], the first part of $\partial c/\partial\tau$ in equation [a.6] can be rewritten as :

[a.1.10] $$[(p^t\text{-}p^w)/\alpha]\,[\partial p^t/\partial\tau - \partial p^w/\partial\tau] = -\,\delta\,(1/\alpha)\,[(1/\pi)/((1/\alpha)+(1/\pi))]\,[(p^t\text{-}p^w)^2 / (p^t\text{-}p^m)],$$

which is negative for $t > 0$.[10]

With $p^c = p^x - (\pi/\alpha)(p^t - p^m)$ and using [a.7] and [a.9], the second part of $\partial c/\partial\tau$ in equation [a.6] can be rewritten as :

[a.1.11] $$[(p^w - p^c)/\pi]\,[\partial p^w/\partial\tau - \partial p^c/\partial\tau] = -\,\delta\,[(1/\alpha)/((1/\alpha)+(1/\pi))]\,[(p^t\text{-}p^w) / (p^t\text{-}p^m)],$$

which is negative for $t > 0$. Hence we can conclude that, for $t > 0$, $\partial c/\partial\tau < 0$, i.e. deadweight costs for a given level of transfer decrease with an increase in public research investment. Furthermore, it turns out that $c_{\tau t} = \partial c_\tau/\partial t < 0$.[11]

A. 2 Import tariff in a small open economy

The deadweight costs c associated with transfer t with an import tariff are:

[a.2.1] $$c(t) = (p^t - p^w)^2 / 2\alpha + (p^t - p^w)^2 / 2\pi = [(1/\alpha) + (1/\beta)](p^t - p^w)^2/2.$$

[a.2.2] $$\partial c/\partial t = [(1/\alpha) + (1/\beta)].(p^t - p^w).\ \partial p^t/\partial t$$

With $\partial p^t/\partial t = \alpha/(p^t - p^m) > 0$, it follows that $\partial c/\partial t > 0$ for an import tariff ($t > 0$) and $\partial c/\partial t < 0$ when $t < 0$ (e.g. in the case of an export tax). Further, we can derive that

[a.2.3] $$\partial^2 c/\partial t^2 = [(1/\alpha) + (1/\beta)][\partial p^t/\partial t]^2\,[(p^w - p^m)/(p^t - p^m)] > 0$$

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10 Notice that this sign can be directly obtained from condition [14]. Define $P = (p^w - p^m)/(p^t - p^m)$, which implies that $P < 1$ if agriculture is subsidized, i.e. if $t > 0$ (and assuming that $p^w > p^m$ and $p^t > p^m$). Combining condition [14] and $P < 1$ implies that $\partial p^t/\partial\tau - \partial p^m/\partial\tau < \partial p^w/\partial\tau - \partial p^m/\partial\tau$ and that the first part of $\partial c/\partial\tau$ in equation [13] is negative.

11 <u>To show</u>: $c_{\tau t} = \partial c_\tau/\partial t < 0$ (proof is available upon request).

Therefore, this example is consistent with the assumptions of our model.

The impact of public investment τ on deadweight costs c associated with transfer policy t, for a given level of t, is:

[a.2.4] $$\partial c/\partial\tau = [(1/\alpha) + (1/\beta)]\,(p^t - p^w)\,\partial p^t/\partial\tau$$

To determine the sign of $\partial c/\partial\tau$ we use the fact that t remains constant (ceteris paribus), i.e.

[a.2.5] $$\partial t/\partial\tau = [(p^t - p^m)/\alpha]\,[\partial p^t/\partial\tau - \partial p^m/\partial\tau] - [(p^w - p^m)/\alpha]\,[\partial p^w/\partial\tau - \partial p^m/\partial\tau] = 0,$$

which implies that

[a.2.6] $$\partial p^t/\partial\tau = -\delta[(p^t - p^w)/(p^t - p^m)]$$

where $\delta = - dp^m/d\tau$ reflects the productivity of the investment function. It follows $\partial p^t/\partial\tau >,=,< 0$ for t <,=,> 0, assuming that prices never fully prohibit domestic production (i.e. $p^t > p^m$ always).

Combining [a.2.4] and [a.2.6] yields that $\partial c/\partial\tau < 0$ for both $t > 0$ and $t < 0$, i.e. deadweight costs for a given level of transfer decrease with an increase in public investment. If tariffs are zero, obviously there is no effect of τ on deadweight costs ($\partial c/\partial\tau = 0$ for $t = 0$).

We also calculate $c_{\tau t}= \partial^2 c/\partial\tau\partial t$. Using [a.2.6] we first derive that

[a.2.7] $$\partial^2 p^t/\partial\tau\partial t= \delta.\ [(p^w - p^m)/(p^t - p^m)^2]\partial p^t/\partial t.$$

With $\partial p^t/\partial t > 0$ and $\delta > 0$ this implies that $\partial^2 p^t/\partial\tau\partial t > 0$. We use this to derive that

[a.2.8] $$\partial^2 c/\partial\tau\partial t = - \delta\,[(1/\alpha) + (1/\beta)].[(p^t - p^w)^2/ (p^t - p^m)^2]\,\partial p^t/\partial t < 0$$

In conclusion, $c_\tau < 0$ and $c_{\tau t} < 0$ always (unless $t = 0$), while $c_t > 0$ for $t > 0$ and $c_t < 0$ for $t < 0$

A. 3 Fixed price support cum (variable) export subsidies in a large open economy

Define foreign excess demand $Q^{ed}(p) = (p^z - p)/\gamma$, where p^z is the intercept with the vertical axis and γ the absolute value of the slope of the excess demand curve. The free market equilibrium price p^w is determined as

[a.3.1] $$p^w = [(p^m/\alpha) + (p^x/\pi) + (p^z/\gamma)] / \Omega$$

where $\Omega = [(1/\alpha) + (1/\pi) + (1/\gamma)]$. It follows that

[a.3.2] $$e^A{}_\tau = \delta\,Q^s(p^w)\,[(1/\pi)+(1/\gamma)]/\Omega \quad \text{and}$$

$$e^{B}_{\tau} = \delta\, Q^s(p^w)\,(1/\alpha)/\Omega.$$

This implies that producers gain less than consumers from an increase in public investment ($e^{A}_{\tau} > e^{B}_{\tau}$) if $Q^d(p^w)/Q^s(p^w) > [(1/\pi) + (1/\gamma)]/(1/\alpha)$. This is more likely to occur when the self-sufficiency ratio is greater, when domestic and foreign demand are less elastic (i.e. smaller π and γ) and when supply is more elastic (larger α). These conditions are characteristics of agriculture in developed countries, such as the EU and North America.

Consider now the case when the government imposes a minimum guaranteed price p^t sustained by a variable export subsidy or import tariff, which is the difference between p^t and the effective world market price p^c. Transfer t is:

[a.3.3] $$t = t^A = [(p^t - p^m)^2 - (p^w - p^m)^2] / 2\alpha$$

Total deadweight costs c associated with t are:

[a.3.4] $$c(t) = (p^w - p^c)\, Q^x(p^t) + (p^t - p^w)^2 / 2\alpha + (p^t - p^w)^2 / 2\pi$$

where the first term represents subsidies to foreign consumers. The second and third term represent domestic consumption and production distortions.

The impact of public investment τ on c of transfer policy t, for a given level of t is:

[a.3.5] $$\partial c/\partial\tau = [(p^w-p^c)\partial Q^x/\partial\tau + Q^x(\partial p^w/\partial\tau-\partial p^c/\partial\tau)] + [(1/\alpha)+(1/\pi)]\,[(p^t-p^w)(\partial p^t/\partial\tau-\partial p^w/\partial\tau)]$$

Analogous to the target price and deficiency payments case we can show that the second part of [a.3.5] is negative, given the result that

[a.3.6] $$\partial p^w/\partial\tau - \partial p^m/\partial\tau = \delta\,[(1/\pi)+(1/\gamma)]/\Omega > 0,$$

under the open economy situation. To determine the sign of first part of [a.3.5], first rewrite

[a.3.7] $$\partial p^w/\partial\tau-\partial p^c/\partial\tau = (\delta\gamma/\Omega)\,[(1/\alpha)+(1/\pi)][(1/\pi)+(1/\gamma)]\,(P-1)$$

which is negative for t>0 (P<1); and

[a.3.8] $$\partial Q^x/\partial\tau = (\delta/\Omega)\,\{[(1/\alpha)+(1/\pi)][(1/\pi)+(1/\gamma)]\,(P-1) + (1/\alpha)(1/\gamma)\}$$

The first part of [a.3.8] is negative for t>0 (P<1), but the second part is always positive. Therefore, the sign of $\partial Q^x/\partial\tau$ cannot be determined unambiguously. It is more likely to be negative if protection is higher (P lower) and if domestic demand is more elastic (π smaller). If supply and foreign demand are more elastic (α and γ smaller) the last (positive) term increases, but also the first term.

Combining these results shows that all terms in [a.3.5] are negative except for the last term of [25], which we just discussed. Combining all terms yields the following:

[a.3.9] $$\partial c/\partial\tau = (\delta/\Omega) \{ [Q^x(p^t) - Q^x(p^w)] [(1/\alpha)+(1/\pi)+\gamma] [(1/\alpha)+(1/\pi)][(1/\pi)+(1/\gamma)] (P-1)+ Q^x(p^t) \gamma [(1/\alpha)+(1/\pi)][(1/\pi)+(1/\gamma)] (P-1) + [Q^x(p^t) - Q^x(p^w)] (1/\alpha) \}$$

in which all terms are negative for $t>0$ ($P<1$), except for the last term $[Q^x(p^t) - Q^x(p^w)] (1/\alpha)$. The aggregate effect $\partial c/\partial\tau$ is more likely to be negative if protection is higher (P lower) and if domestic demand is more elastic (π smaller). If supply is more elastic (α smaller) the last (positive) term increases, but also the first terms. Recall that we are analysing the situation under which $\beta^A < \beta^B$, which is more likely when demand is more elastic (π smaller) and supply is less elastic (α larger). Under these conditions, $\partial c/\partial\tau$ is likely negative.

Table 1: Impact of Research on Deadweight Costs of Commodity Policy

Commodity Policy	Trade Status	$dc/d\tau$ Commodity Policy Instrument fixed	$dc/d\tau$ Net Income Transfer fixed
Output quota	no trade	+	—
Target price & deficiency payments	no trade	+	—
Output subsidy	no trade	0	—
	small country	0	—
Import tariff	small country	0	—
Fixed price support & variable export subsidy	small country	0	—
	large county	+	?

Table 2: Summary of Results for Alternative Government Objective Functions

Government Objective Function		Small Country Import Tariff	Target price with deficiency payments No trade	
Max. Income s.t. farm income constraint	$\partial c/\partial \tau$	—	—	
	$\partial t^*/\partial \tau$	—	—	
	$dc/d\tau$	—	—	
Max. Weighted Pref. Fn			<u>$\alpha < \beta$</u>	<u>$\alpha > \beta$</u>
	$\partial c/\partial \tau$	—	—	—
	$\partial t^*/\partial \tau$	+	—	+
	$dc/d\tau$	+	—	?
Max. Political Support			<u>$\alpha < \beta$</u>	<u>$\alpha > \beta$</u>
	$\partial c/\partial \tau$	—	—	—
	$\partial t^*/\partial \tau$	—[1]	+[1]	—[1]
	$dc/d\tau$	—[1]	?	—[1]

[1] unless economic interaction effects (EIEs) more than offset political interaction effects (PIEs)

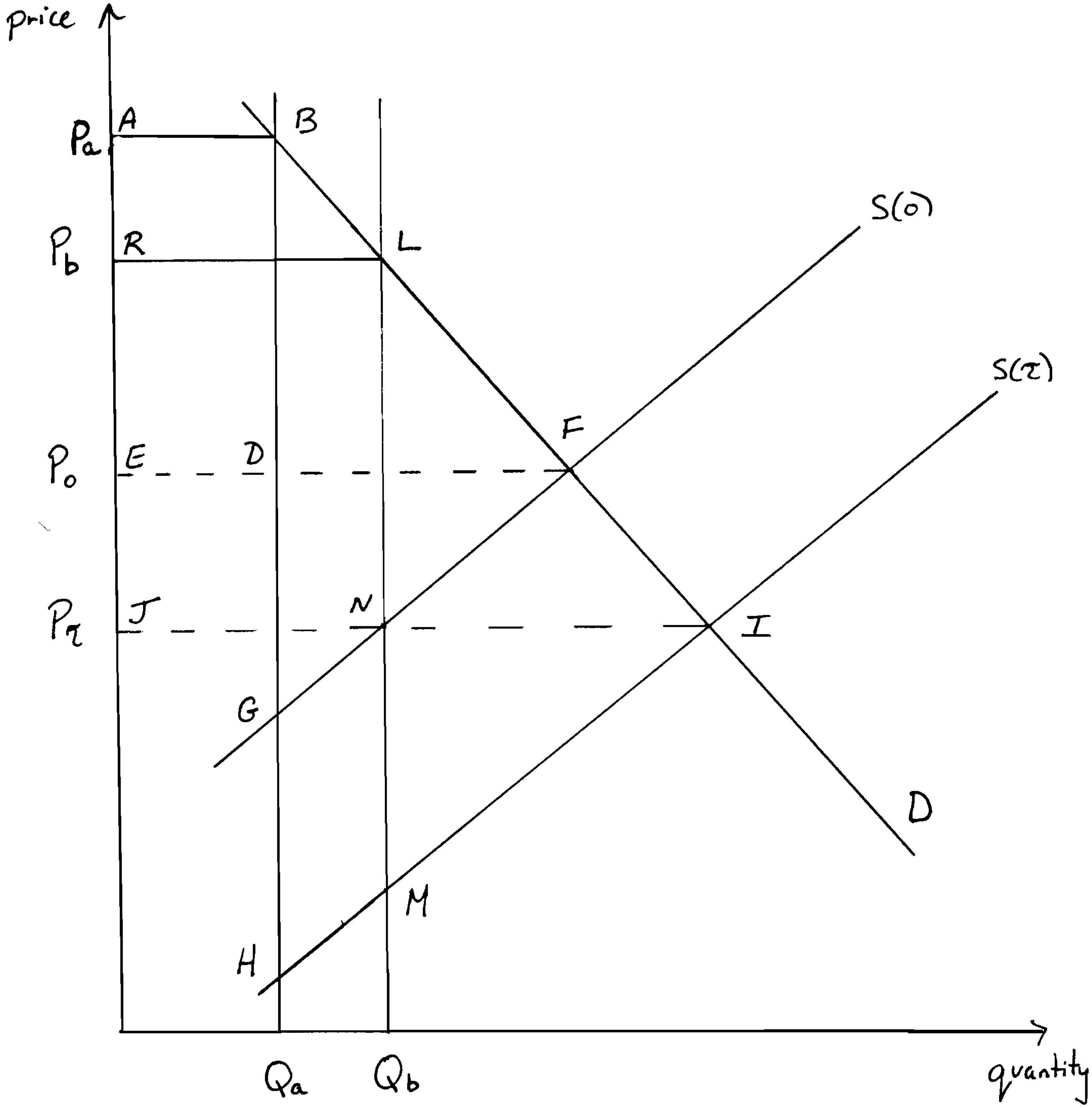

Figure 1: Output Quota (closed economy)

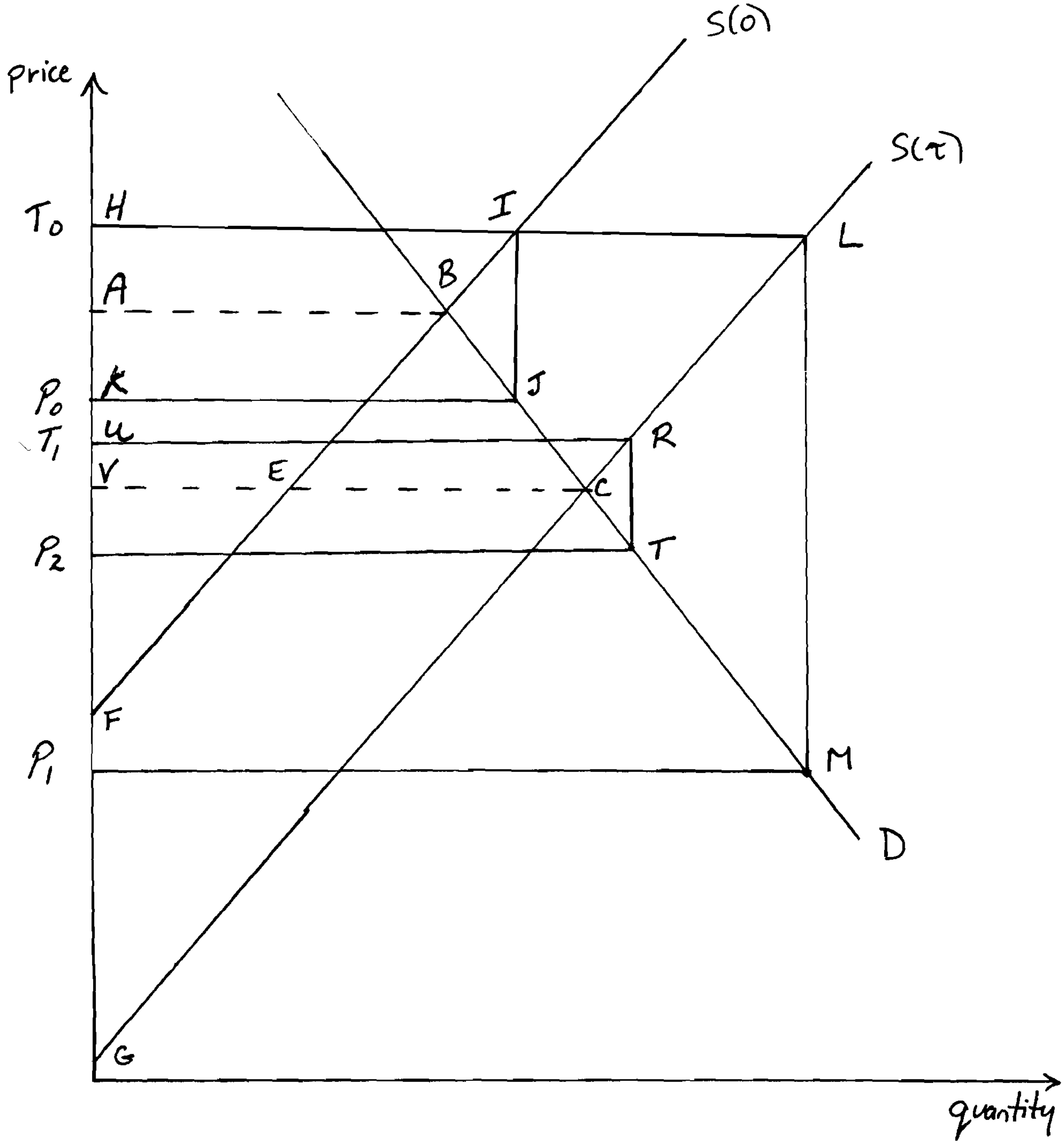

Figure 2: Target Price & Deficiency Payments (closed economy)

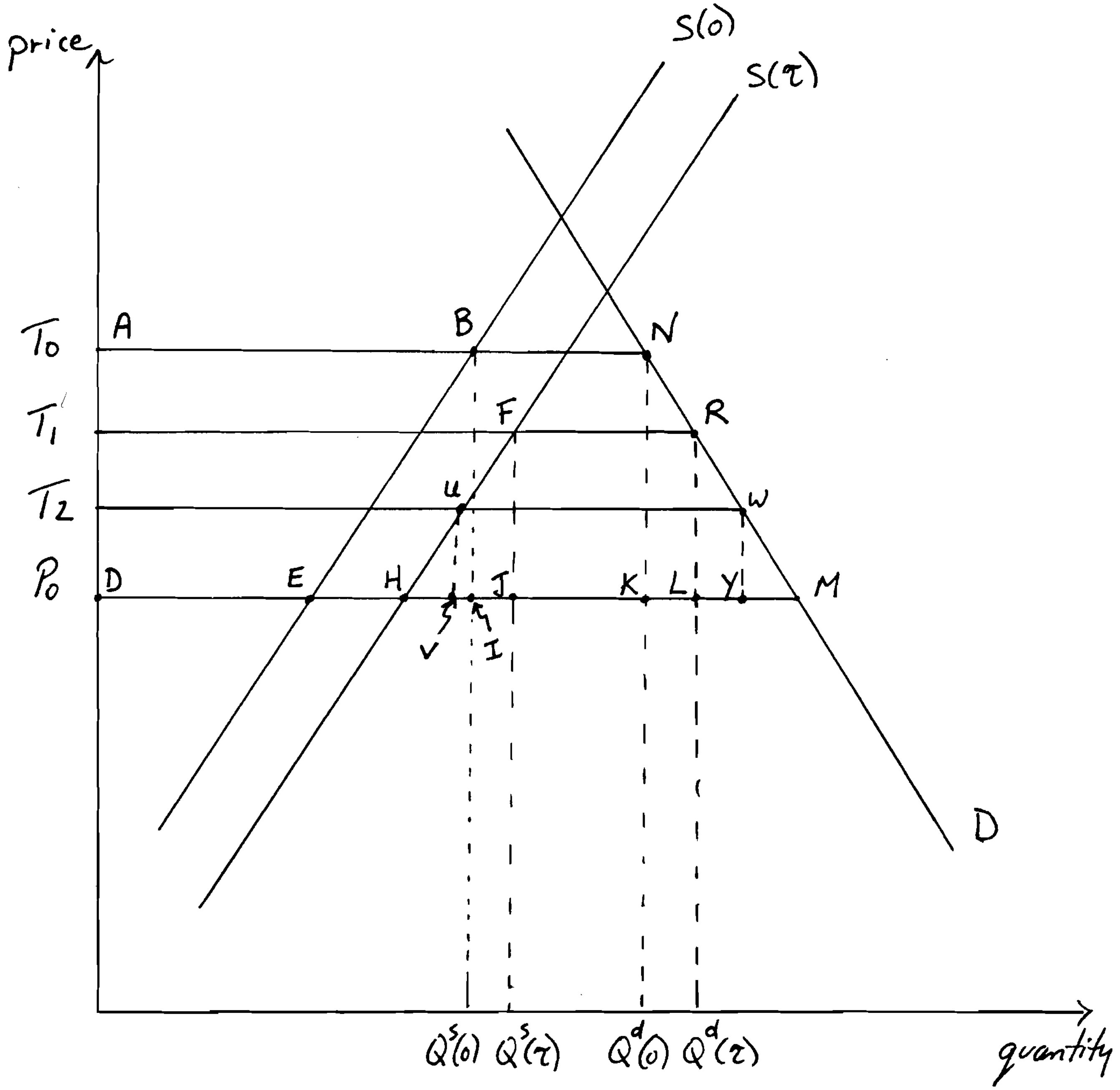

Figure 3: Import tariff (small country)

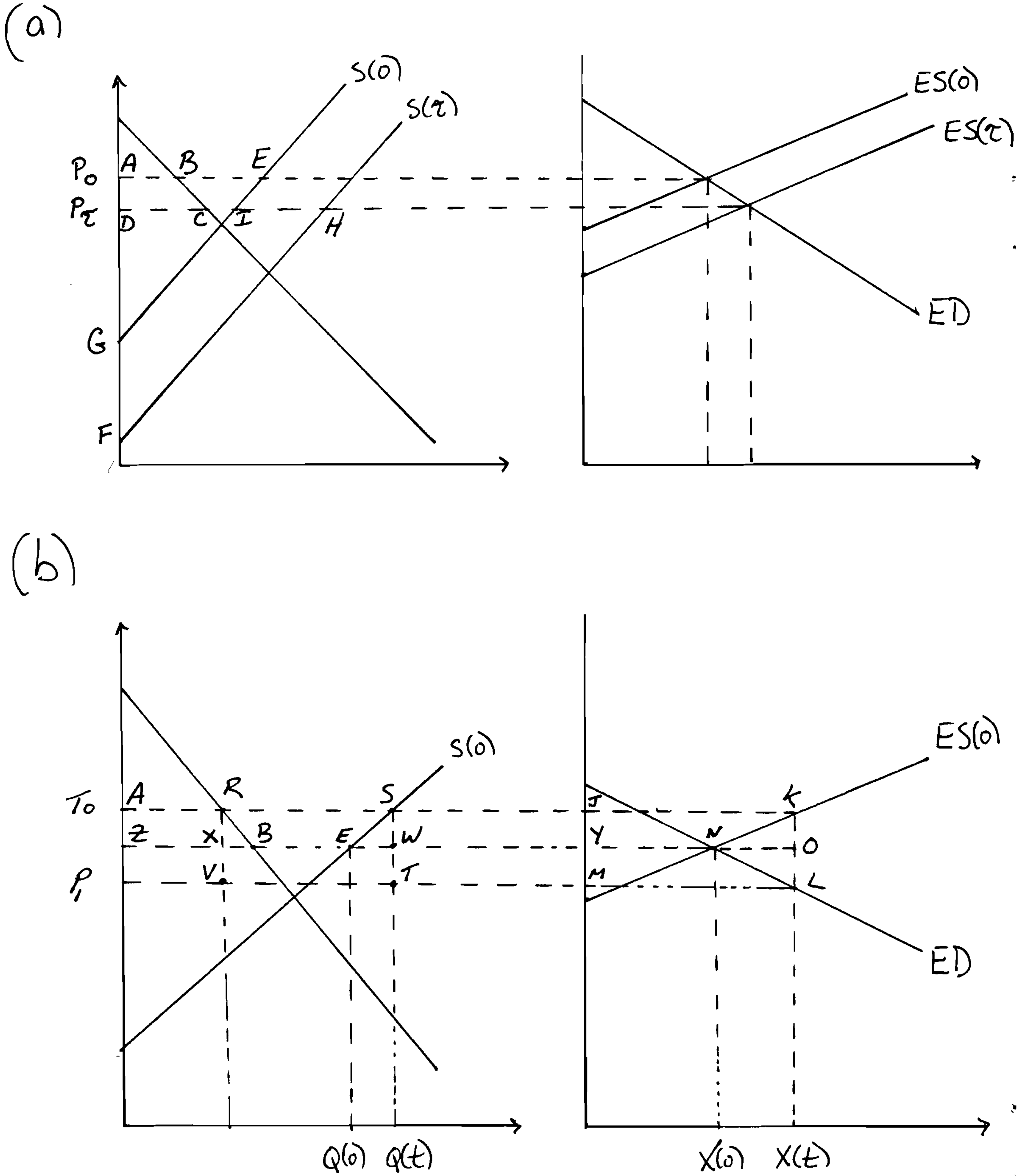

FIGURE 4: Export Subsidy (large economy)

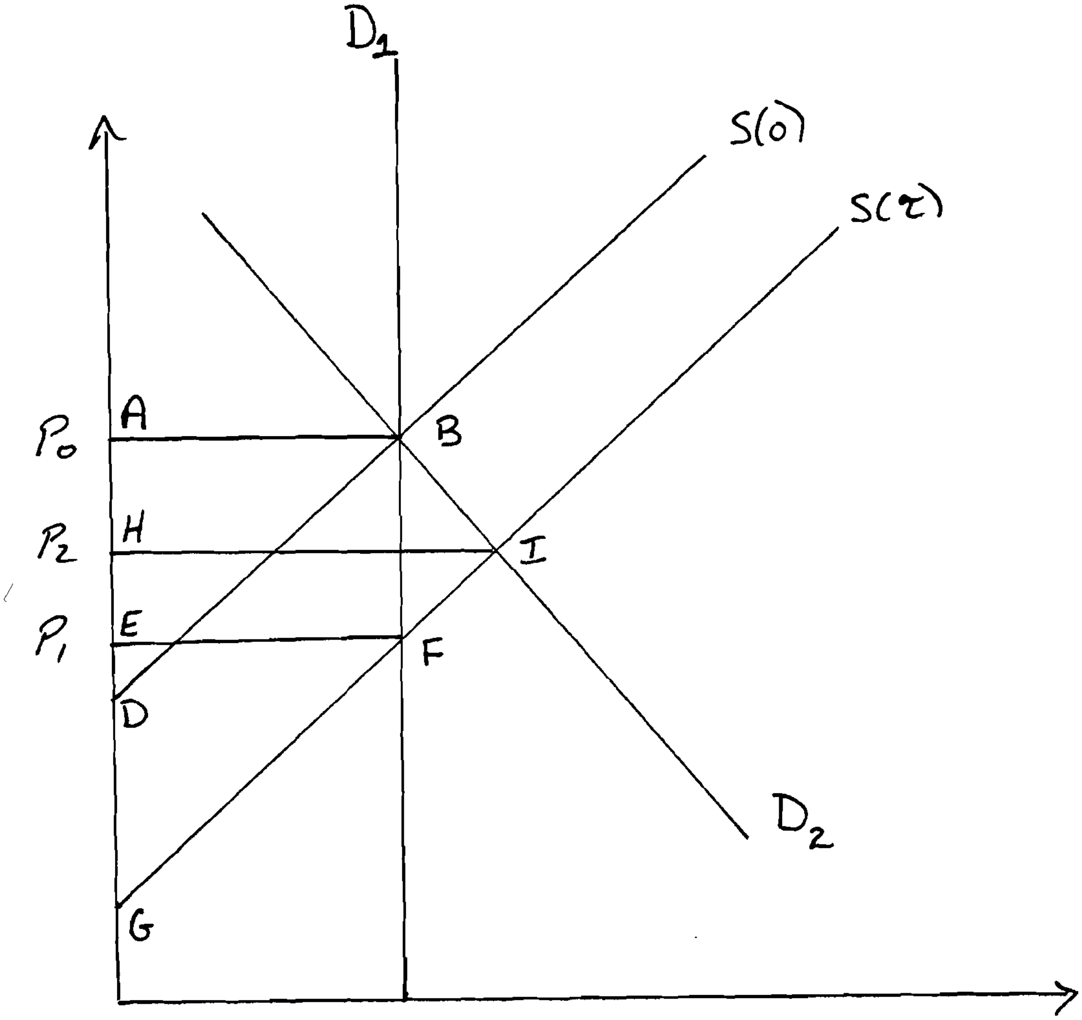

Figure 5: Demand Elasticity & Producer Surplus

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