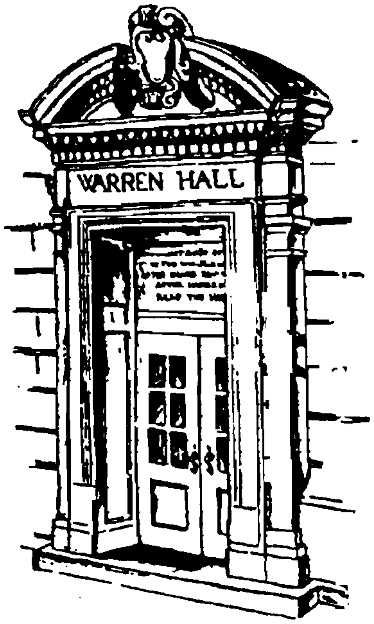
WP 96-20
December 1996



Working Paper

Department of Agricultural, Resource, and Managerial Economics
Cornell University, Ithaca, New York 14853-7801 USA

THE IMPACT OF ECONOMIC DEVELOPMENT ON REDISTRIBUTIVE AND PUBLIC RESEARCH POLICIES IN AGRICULTURE

by

Harry de Gorter and Johan F.M. Swinnen

The Impact of Economic Development on Redistributive and Public Research Policies in Agriculture

by

Harry de Gorter
Department of Agricultural, Resource and Managerial Economics
447 Warren Hall
Cornell University
Ithaca NY USA 14853
tel (607)255-8076
fax (607)2559984
HD15@Cornell.edu

and

Johan F.M. Swinnen
Department of Agricultural Economics
K.U. Leuven
Kardinaal Mercierlaan 92
3001 Leuven, Belgium
tel 011 32 16 32 16 15
fax 011 32 16 32 19 96
Jo.Swinnen@agr.kuleuven.ac.be

22 November 1996

The Impact of Economic Development on Redistributive and Public Research Policies in Agriculture

Harry de Gorter and Johan F. M. Swinnen

Introduction

The effects of commodity policies and agricultural research expenditures on economic efficiency and income distribution have been widely analyzed in the literature. Commodity policies have helped farmers in industrial countries (and consumers in developing countries) at great costs to economic efficiency and huge distortions in world markets (OECD, Johnson, Sumner, Gardner 1987a, Tyers and Anderson, WDR). At the same time, public research investments are an important source of productivity growth in agriculture (Huffman and Evenson (1992, 1993); Ruttan, Alston, Pardey and Norton).[1] Despite the overwhelming evidence of high social rates of return to public research investments, significant underinvestment persists in both developing countries and industrial countries. An important political economy literature has emerged trying to explain the pervasiveness of inefficient commodity policy world-wide and why political incentives induce governments to do as they do (Schultz (1978), Gardner (1987b), Krueger, Schiff and Valdes; de Gorter and Tsur; Swinnen; Lindert; Anderson and Hayami; de Janvry).

In contrast, most of the explanations for sub-optimal public research investment has focused on economic rather than political factors. Explanations include imperfect information of governments, difficulties in overcoming the particular nature of the "publicness" of research (transaction costs), free rider problems and spill-ins between countries (or states within a country). Others have claimed that underinvestment may be overstated because studies ignore deadweight costs of taxation, the country's

[1] Stiglitz (1993) states that the productivity increases induced by public research investments in agriculture have been "little short of an economic miracle".

trade position, terms of trade, the difference between intermediate and finished products, the effects on unemployment, private research effects, and the impact of public research on deadweight costs of commodity policies (Alston, Edwards and Freebairn; Edwards and Freebairn; Fox; Murphy, Furtan and Schmitz; Schmitz and Seckler; USDA).

The objective of this paper is to develop a general political economic model that explains the stylized facts on redistribution through commodity policy and underinvestment in agricultural public research. While public investment in agricultural research has contributed importantly to economic growth, an important aspect of public research expenditures has been its impact on the distribution of income between urban and rural sectors (Cochrane,; Ruttan; de Gorter and Zilberman). Rausser and de Gorter, Nielson and Rausser argue that the political forces affecting commodity policy should therefore also be relevant for public investment policy. This literature also emphasizes the role commodity policies plays in mitigating the distributional effects of research and the importance of an integrated framework for policy analysis.

To account for the distribution effects of both commodity policies and public research, we specify a model of two sectors with competing interests: a rural (agricultural) and an urban (industry) sector. Our framework has commodity policy and public research investment determined jointly. We assume that the policy combination is determined by rational choice, given the political constraints of the government. More specifically, we extend the public choice model of Swinnen and de Gorter (1993) and Swinnen by introducing public research investment as a second policy. This approach assumes that governments maximize political support and that this political support is a concave and increasing function of policy-induced changes in welfare. These, in turn, depend on the structure of the economy and specific policy. This approach ensures a stable and unique equilibrium within a two-policy framework and allows for comparative static analyses to derive the impact of structural changes in the economy which coincide with economic development.

The joint determination of commodity policy and public research investment generates two types of "interaction effects". Public investment such as productivity increasing research can affect the deadweight costs of commodity policy.[2] We define this as the "economic interaction effect (EIE)" as the change in deadweight costs per unit of transfer induced by the public research investment. There is another interaction effect between policies through how politicians make decisions with respect to changes in political support levels. Each policy affects the political support for the other policy, and so there is an incentive for politicians to change the level of the other policy. We will call this the "political interaction effect (PIE)". For example a change in research investment will affect the politically optimal commodity policy through its effect on the marginal political support levels, and, vice versa. Both interaction effects influence the politically optimal policy combination.

The paper first presents a two sector-two policy model and then derives the social and political optimal policy combinations. In the following sections the impact of economic development on the optimal policy combinations is derived. The last section discusses implication of our analysis for the general literature on endogenous growth.

The Model

Consider an economy with 2 sectors: agriculture (sector A) and industry (sector B). All individuals in the economy have identical preferences and maximize an indirect utility function $U(y^i)$, where y^i represents net income of individual i. Each sector has one representative individual with a

---

[2] We ignore the important issue why redistribution takes place through distortionary commodity policies and not through lump-sum transfers. Foster and Rausser (1993) show that price and trade policies can be a preferred policy to lump sum transfers when redistribution is used to reduce opposition to growth promoting policies by selectively compensating for adverse income effects.

pre-policy 'endowment' income y^i_e (for i = A, B). The government has two policy instruments affecting incomes in the economy: public agricultural research investment (PARI) and redistribution through commodity policies. While PARI is typically considered a public good with many agricultural producers that increases productivity, PARI also has an important impact on income distribution. Denote τ as the level of the PARI and g^i as individual i's aggregate net benefits from PARI defined by a research production function f:

$$[1] \quad g^i(\tau) = \beta^i f(\tau) - \tau/2$$

where β^i determines each sector's per capita share of the benefits derived from the public good investment with $\beta^A + \beta^B = 1$. The second term $\tau/2$ indicates that taxes to finance the investment τ are shared equally by individuals. We ignore deadweight costs of taxation in raising funds for the PARI.

Redistributive policies between sector A and B involve deadweight costs. Typical commodity policies in agriculture include price supports, export subsidies and trade barriers. Denote $t^i(t)$ as the *aggregate net* income transfer for individual i resulting from commodity policy t. Note that $t^i(0) = 0$, and $t^A(t) = t$ and $t^B(t) = - t - c(t)$, where c(t) represents the deadweight costs of the commodity policy. Hence, commodity policy t represents the aggregate net income transfer to agriculture. Thus, t is positive when agriculture is subsidized as in industrial countries. Furthermore, we assume that $c_t > 0$ for $t > 0$, $c_t < 0$ for $t < 0$, $c_{tt} > 0$ and $c(0) = c_t(0) = 0$.[3] If τ affects for example the supply function in one of the sectors, then it will affect c for a given level of the redistributive policy. This in turn will affect the net sector transfer t^i. The impact of both policies on sector i's net income y^i is given by:

[3] These assumptions are consistent with several widespread commodity policies, such as import tariffs (Swinnen and de Gorter, 1995b).

[2] $y^i = y^i_e + t^i(t,\tau) + g^i(\tau)$

Because each policy has a differential impact on the distribution of income, preference for PARI and the commodity policy differs between sectors.

The Social Optimum

The optimal policies for a social planner are determined by maximizing total income. Define $\{\tau^m, t^m\}$ as the *social optimal* policies which maximize national income $Y = y^A + y^B$. Maximizing national income implies that $t^m = 0$ with τ^m determined by the following condition[4]:

[3] $y_\tau^A(\tau^m) + y_\tau^B(\tau^m) = 0.$

which can be simplified to

[4] $f_\tau(\tau^m) = 1.$

The Political Optimum

A burgeoning literature in political economy specifies a government maximizing some form of a political objective function (Hillman; Alesina and Rodrik; Persson and Tabellini; Rausser). We generalize the Downsian public choice model used by Swinnen and de Gorter (1993) and Swinnen in analyzing redistributive policy to include PARI. The political support politicians receive from citizens is postulated to depend on how each policy affects the economic welfare of individuals in each group. Citizens increase their political support if they benefit from the policies and reduce support otherwise.

---

[4] Without deadweight costs (c = 0), t^m is not uniquely determined as each t yields the same Y. With deadweight costs, $t^m = 0$ is the only optimum.

Formally, individual political support S^i is assumed to be a strictly concave and increasing function of the policy induced change in welfare $V^i(t,\tau) = U^i(t,\tau) - U^i(0,0)$:

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

The functions $S^i(.)$, $U^i(.)$, and therefore $V^i(.)$, are continuous, at least twice continuously differentiable, strictly increasing and strictly concave. An important advantage of this specification is that it avoids indeterminacy and multiple equilibria problems which are typical of deterministic (0-1) voting models (Mueller; Coughlin) and of multiple policy problems (Mayer and Riezman, 1987). We assume that S^i is identical for all individuals, the implications of which are discussed later.

In order to stay in power, politicians need to obtain a minimum level of political support. This depends critically on political institutions that determine the rules of the game for political decision-making. Under autocratic political institutions, such as dictatorships, political support from a large part of the constituency may not be needed to stay in power. In general, a more democratic society has more competition between politicians, resulting in politicians giving consideration to the impact on political support from their constituency. Under perfect competition, politicians will choose the policy combination $\{t^*,\tau^*\}$ that maximizes political support in order to stay in power. For our model, this implies the following decision problem for politicians:

[6] $$\max_{t,\tau} \; S[V^A(t,\tau)] + S[V^B(t,\tau)]$$

subject to the government budget constraint.[5] We refer to the policies t* and τ* that solve this problem as the *politically optimal* policies. The first order conditions for the politically optimal commodity policy t* and for the politically optimal public investment τ* are, respectively:

[7] $S_V^A(t^*)\, U_V^A(t^*) - S_V^B(t^*)\, U_y^B(t^*)\, (1 + c_t(t^*)) = 0$

[8] $S_V^A(\tau^*)\, U_V^A(\tau^*)\, g_\tau^A(\tau^*) + S_V^B(\tau^*)\, U_y^B(\tau^*)\, (g_\tau^B(\tau^*) - c_\tau(\tau^*)) = 0$

where $S_V^i = \partial S/\partial V^i$ and $U_y^i = \partial U/\partial y^i$. The size and sign of t* and τ* depend, *inter alia*, on the relative pre-policy endowment incomes between agriculture and industry, on the distributional impact of the public investment, and on the deadweight costs associated with the commodity policy. To understand how this model can explain the correlation between economic development and changes in the observed (political equilibrium) policy combinations, we first need to understand how economic development affects the key exogenous variables described above.

Economic Development and Distribution of Research Benefits

Economic development affects the distribution of the benefits from PARI in a very important way. De Gorter and Zilberman show that the relative values of β^i depend on the elasticity of supply and demand and on the effects of research on agriculture's cost structure. For example, a large cost reduction in agriculture due to research with an inelastic demand could have consumers benefiting more than farmers. We know that the richer the country, the more price inelastic is food demand because of the relationship between income and price elasticities given by the Cournot condition in demand theory.

---

5 In reality, the two policies may be decided by different parts (e.g. administrations) of the government; they may have different time (dynamic) effects and private research is also undertaken. To capture the essence of these features, we assume that agents have perfect foresight in including future costs and benefits in their valuations. Even if different institutions are involved in the decision-making, those institutions do not act independently of one another as they take each others actions into account. Our specification is a simplified way of modelling this.

Furthermore, industrial countries have relatively elastic supply curves for agriculture while supply is extremely inelastic in developing countries (Binswanger et. al.). In this perspective, Schultz (1953) distinguishes the 'farm problem' in industrial countries where farmers benefit relatively less from technology with inelastic demand from the 'food problem' in developing countries with elastic demand. This implies that one would expect $\beta^A < 0.5$ in industrial countries (research favors the urban group) while $\beta^A > 0.5$ in developing countries (farmers benefit relatively more from research than the urban group).

Impact of Changes in the Distribution of Research Benefits

To analyze the impact of changes in the distribution of research benefits, we first assume that endowment incomes are equal in both sectors ($y^A_e = y^B_e$) and that there is no commodity policy ($t = 0$). The impact of the distribution of research benefits on the political optimal research investment can be summarized by:

Result 1: *If the distribution of research benefits is equal ($\beta^A = \beta^B$), then support maximizing governments will choose the social optimal research investment ($\tau_1^* = \tau_1^m$). In the absence of commodity policies, inequality of research benefits causes the political optimum to <u>always</u> be lower than the social optimal PARI. The more unequal the distribution of research benefits, then a larger gap between the political and social optimal levels of research investment is expected.*

Proof: See appendix.

Recall that we assume each sector shares equally in financing the public good investment and that pre-policy endowment incomes are equal. With equal distribution of research benefits, private optimum levels for research investment are identical in both sectors. Hence, a support maximizing government can only lose political support by diverging from this private optimum, which is also the social optimum. Hence the political optimum and the political optimum coincide in the case where $\beta^A = \beta^B$.

When research benefits are unequally distributed between groups, the political optimum τ^* will always be between each sector's optimum. Consider the case when industry benefits more from research than agriculture because of declining food prices induced by cost-reducing research. Political support maximizing governments will never invest more than industry's preferred level, because both sectors would oppose that. Furthermore, the government will always invest at least as much as agriculture's preferred level (because both sectors support that).

Once the government's investment equals agriculture's private optimum, then industry will support a further increase, but agriculture will oppose further investment in research. An increase in research investment will induce a decrease in support from agriculture and an increase in support from industry. The political optimum is where the marginal increase in support from industry is exactly offset by the marginal reduction in agriculture's political support, as indicated by condition [8]. Given the support function as we have specified it, the political optimum will be less than the social optimum.

The reason is what we have called the "conservative nature" of the political support function (Swinnen and de Gorter, 1993). Conditions [7] and [8] indicate that the marginal political support levels S_v^i play the same role in the equilibrium condition as welfare weights would play in a typical weighted welfare function. However, the key difference is that in our political support function, the "weights" are not constant, but a function of the policy level itself. More specifically, with agriculture benefiting less than industry from PARI ($\beta^A < \beta^B$), S_v^A increases and S_v^B decreases with τ beyond agriculture's private optimum investment level. Therefore, the political weight of the "taxed" group increases while the political weight of the group benefiting decreases when the government increases PARI. At some point, the marginal gain in political support from industry for the government by increasing τ is fully offset by the marginal loss in political support from agriculture. With the increasing "political weight" of the group benefiting least, this point will always arrive before the social optimum τ^m is reached. This "conservative" effect is stronger when the distributional effects of research are larger, causing the gap between the social and political optimal investment levels to increase.

Figure 1 illustrates this result by running several simulations[6]: the social optimal investment τ^m is always equal to 5 and is unaffected by the distributional effects of research. The politically optimal level of public investment τ^* (with $t = 0$) is equal to the social optimal investment τ^m only when the research benefits are distributed equally, i.e. when agriculture gets 50% of the research benefits ($\beta^A = 0.5$). As soon as the distribution is unequal, the political optimal level is less than the social optimum, and the difference increases with growing inequality of research benefits between sectors. For example, if agriculture gets only 10% of the public good benefits, $\tau^* = 3.2$ if no redistribution is allowed ($t = 0$).

Joint Policy Decision-Making and Interaction Effects

We will now extend the analysis by including the joint determination of both the research investment and the redistribution through commodity policies, and their interaction effects. We first analyze how the distributional effects of research not only affects the politically optimal research investment, but also the politically optimal commodity policy. Furthermore, the endogenous redistribution through commodity policies induces a shift in the political optimal research investment.

The joint determination of commodity policy and public investment generates two types of "interaction effects". First, there is an interaction effect between policies through how politicians make

[6] The numbers and curves in figures 1,2,4 and 5 are based on simulations in which specific functions were used for the general model developed in equations (1)-(8). All specifications are consistent with the assumptions made for the general model (see Appendix A.2 for details).

decisions with respect to changes in political support levels. Each policy affects the political support for the other policy, because S_v^A and S_v^B in conditions (7) and (8) are functions of both τ and t, and so there is an incentive for politicians to change the level of the other policy. We will call this the *"political interaction effect (PIE)"*. Second, public investment such as productivity increasing research can affect the deadweight costs of commodity policy. We define this *"economic interaction effect (EIE)"* as the change in deadweight costs per unit of transfer induced by the PARI, i.e. $\partial c/\partial \tau$. When there is no economic interaction effect, $\partial c/\partial \tau = 0$.

In the next section we first consider how the PIE affects the politically optimal policy combination while ignoring the EIE (i.e. we assume that $\partial c/\partial \tau = 0$). In the subsequent section, we study how the inclusion of EIEs will affect the results as well.

The Impact of Political Interaction Effects (PIEs)

The first political interaction effect is when PARI with unequal distributional effects which induces an endogenous redistribution (using commodity policy) from the sector which benefits relatively more from PARI to the sector that benefits relatively less. The level of redistribution is determined both by the importance of the inequality generated by PARI and the level of the PARI:

Result 2: *Agriculture is taxed if it benefits relatively more from PARI (and vice versa).*

Proof: See appendix.

If agriculture benefits less from research ($\beta^A < \beta^B$), then its marginal political support level will be higher than industry's at the politically optimal research investment. As explained above, this arises because a sector's marginal support increases when this group benefits less from policies, and vice-versa. Hence, the marginal support level will increase for those who are being taxed because the public investment level is higher than their optimum. Notice that the marginal support levels are endogenous in the politician's decision process and will be affected by all policies. Consequently, as the ratio of marginal political support levels adjust with changing investment (in condition [8]), it will also affect the optimal redistribution levels (in condition [7]). In this case, it would imply that $S_v^A > S_v^B$ as agriculture is benefiting less from research than industry. Condition [7] then implies that the government transfers income to agriculture ($t^* > 0$) in this case of $\beta^A < \beta^B$. This result holds in general: the political support mechanism will induce the government to compensate the sector that benefits less from research by transferring income to this sector. Figure 2 shows how agriculture is subsidized when it gets less than 50% of the research benefits. This subsidy increases when its share declines further (and vice versa).

So far we have established that the sector benefiting less from research will be compensated through commodity policy. The next question is: *how does the commodity policy affect the politically optimal public investment?* Is there another PIE which causes a reverse impact, i.e. does the existence of commodity policies affect the political optimal public investment τ^*?

Result 3 : *Commodity programs that allow a government to compensate a sector that benefits less from public investment will increase the politically optimal public investment.*

Proof: see appendix

When the government can compensate the sector which is benefiting less from PARI through the commodity policy t, the opposition of this sector to increasing τ is mitigated. As a consequence, the government can increase public investment from $\tau^*(t = 0)$ to $\tau^*(t^*)$.[7] What are the mechanisms behind

[7] The fact that the new investment level is closer to the social optimal investment does not necessarily imply that the social welfare increases. This is due to the fact that, at the same time when transfer t causes research investment to

this? Assume again that agriculture is benefiting relatively less from research. Hence agriculture is taxed by the political optimal PARI level which is beyond its private optimum. Consequently agriculture has a higher marginal political support at the equilibrium investment level *before the endogenous redistribution* (i.e. with $t = 0$). When income is transferred from industry to agriculture through the endogenous redistributive policy, the marginal support levels will adjust again. The commodity policy benefits agriculture, whose marginal political support will therefore go down; while industry, which is taxed by the commodity policy, has its marginal political support go up. This realignment of political support will cause an increase in PARI with the initial increase in the transfer t. The new equilibrium will be established with $\tau^*(t = 0) < \tau^*(t^*) \leq \tau^m$. This is illustrated in figure 1 with the DWC curves in between the $\tau^*(t = 0)$ and τ^m curves. The corresponding transfers are indicated in figure 2.

The Impact of Commodity Policy Deadweight Costs

Result 4: *The stimulating effect of endogenous redistribution on PARI is negatively related to the distortions (per unit of transfer) caused by the commodity policy.*

Proof: see appendix.

Deadweight costs create a wedge between the benefits of the transfer t and the losses of the transfer t. Hence, the reduction in political support from the sector which is taxed will be larger and the increase in political support from the gainers of the transfer will be smaller. As a consequence, the optimal transfer t^* will be less with more distortions, and also the resulting optimal investment $\tau^*(t^*)$ will be

---

go up, it also causes total deadweight costs to go up. The net effect depends on the inequality of the research distribution, on how distortionary the policy is and on the EIEs (Swinnen and de Gorter, 1995b).

less with a more distortionary transfer policy. Figures 1 and 2 illustrate how deadweight costs change the politically optimal policy combinations: $\tau^*(t^*)$ varies between the social optimum level ($\tau^m = 5$) and the $\tau^*(t = 0)$ level, depending on the deadweight costs associated with the transfer. With increasing deadweight costs, the politically optimal public investment declines and $\tau^*(t^*)$ is closer to $\tau^*(t = 0)$. This is illustrated by the DWC2-curve which is closer to the $\tau^*(t = 0)$-curve than the DWC1-curve, with DWC2 representing higher deadweight costs per unit of transfer than DWC1.

When non-distortionary (lump-sum) transfers can be used as a redistributive policy, the endogenous redistribution mechanism in our political economy framework will result in politically support maximizing governments choosing the social optimal investment level always, i.e. $\tau^*(t^*) = \tau^m$ when DWC = 0. The reason is that with lump-sum transfers the government can use the transfer as a perfect compensation mechanism, allowing for full compensation of the distributional effects of public research. Hence, research policy induced inequality will be fully compensated by the endogenous redistribution. The result is that the reduction in political support which would occur from investing more than a sector's optimum is fully offset by the increase in political support by increased transfers to this sector, leading to the unchanged optimum $\tau^*(t^*) = \tau^m$ for the government, regardless of the distributional effects. In summary:

Result 5: *With non-distortionary transfer policies the political support maximizing government will choose the social optimal level of public investment.*[8] *In all other cases (DWC > 0) the gap between political and social optimal research investment increases with growing inequality of research benefits -- even with endogenous redistribution.*

[8] This result is conditional on the static nature of the analysis. In a dynamic framework underinvestment will result even without DWC because of government credibility problems in compensation (Swinnen and de Gorter, 1995a).

Proof: see appendix

Implications for Policy Instrument Choice and Economic Development

The extreme ends of economic development results in large unequal distribution of research benefits (Figure 2). The result is a demand and hence a supply of redistributive policies in the form of distortionary commodity policy (tax farmers in poor countries and subsidize farmers in rich countries). The transfer policy induces deadweight costs, something rich countries can better afford on a relative basis than their poor country counterparts. Furthermore, the deadweight costs differ between various policy instruments, and hence the benefits of policy reform (i.e. the shift to a less distortionary commodity policy) increase as well, both in terms of reduced deadweight costs and in terms of more PARI which is now possible with a less distortionary commodity policy.

Typical policy reforms in the past involve important costs in adjusting administration, human capital, institutions and the like. Figure 1 indicates that as the extreme ends of economic development coincides with a large inequality in research benefits, the benefits of policy reform are also large and may outweigh the political costs of policy reform at some point. A classic example is the growth of agricultural production in European Union over the past 50 years whereby increased productivity has shifted agriculture into a net exporter position. This increases the deadweight cost per unit transfer because the international terms of trade deteriorate as subsidies increase. Likewise, farm structure has changed such that relative rural-urban incomes have increased in several countries. The result is political pressure for policy reform.

In the European Union's case, import tariffs improved their terms of trade in the early years and so subsidies involved relatively low deadweight costs (and bypassed public budget expenditures). Technical change (induced in part by PARI in European Union and world-wide) caused a huge increase in subsidy costs, thereby generating a change in policy instruments. First, import tariffs were replaced by import and production quotas (along with other quantitative restrictions on the amount receiving subsidies like 'maximum guaranteed quantities'). Now price supports are being reduced and the quantity receiving payments are being increasingly separated from the level of production. So unequal benefits of research early on induced more transfers but the costs of the transfers resulted in more efficient and modest transfer or commodity policy. The benefits from research reached the public in this endogenous policy world, with commodity policy first compensating for technical change and inducing more PARI than otherwise would have been the case.

The Impact of Economic Interaction Effects

Economic interaction effects (EIEs) occur if the PARI affects the deadweight cost of commodity policy, i.e. $\partial c/\partial \tau \neq 0$. Now there is an additional effect affecting the income distribution of the PARI and thus the political equilibrium PARI level (as indicated by equation (8)). The impact of the PARI on deadweight costs of commodity policy is widely discussed in the literature with most papers arguing that the PARI *increases* deadweight costs (Alston, Edwards and Freebairn; Murphy, Furtan and Schmitz; Chambers and Lopez). However, these conclusions are based on the assumption of a *given policy instrument level*, e.g. a fixed import tariff or production subsidy. Of course, with a cost-reducing research induced supply shift, both producers' incomes and transfers to producers increase with a fixed policy instrument level. Hence, results based on this assumption are irrelevant for our current analysis. We need to know how PARI affects the deadweight costs of commodity policies *per unit of transfer* (or for a fixed transfer level) i.e. $\partial c/\partial \tau$. In general, the impact depends on the commodity policy instrument, on the trade status of the sector and on the nature of the research induced supply shift. However, for a parallel supply shift, which is argued to be the most relevant case[9], virtually all policy-trade status cases yield a negative impact of research on the per unit transfer deadweight costs, i.e. EIE = $\partial c/\partial \tau < 0$ (Swinnen and de Gorter, 1995b).

To illustrate this effect, consider the impact of productivity increasing public investment on an import tariff in a small country with a simple, partial equilibrium model (see figure 3). Agricultural producers are protected as world market price p^w is below the domestic price $p^t(0)$, which is sustained by an import tariff equal to $p^t(0) - p^w$. The demand and supply curves are represented by D and S(0), respectively. Domestic consumption is $Q^d(0)$ and supply is at $Q^s(0)$. The net transfer to the agricultural sector t induced by the import tariff $p^t(0) - p^w$ equals area ABED. Deadweight costs associated with transfer t, c(0), equal the sum of areas BIE and NKM. Now assume that the PARI τ shifts the supply curve from S(0) to S(τ). What happens to deadweight costs? Notice that the shift of the supply curve would induce an increase in transfer t if the import tariff is maintained at $p^t(0) - p^w$. However, as our analysis is *ceteris paribus*, we need to separate the effects of both policies. To analyze the impact of τ on c, we need to keep t constant. In order to keep transfer t constant, the import tariff has to decline to $p^t(\tau) - p^w$ with public investment τ. Domestic prices fall from $p^t(0)$ to $p^t(\tau)$. Consumption and production both increase to $Q^d(\tau)$ and $Q^s(\tau)$, respectively. Deadweight costs c(τ) 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 case when EIE < 0, the benefits for sector B of public research investments increase, because for a given PARI level $\tau°$, sector B's income is now $y_\tau^B(\tau°) = g_\tau^B(\tau°) - c_\tau(\tau°)$. Hence a negative EIE ($\partial c/\partial \tau < 0$) reduces existing deadweight costs and hence, increases B's income. Therefore, this will either reduce sector B's opposition to further public research investment (when β^A

[9] Murphy, Furtan and Schmitz cite a series of studies which show that a parallel shift is more consistent with empirical

$> \beta^B$), or will increase B's support for more PARI (when $\beta^A < \beta^B$). In both cases, condition (8) indicates that EIE < 0 will yield an increase in the optimal level τ^*.[10] The implication is that governments will tend to increase public investment further when commodity policies are used for compensation, because the EIEs ensure that the public investment has a negative effect on deadweight costs per unit of transfer. Figure 1 shows how $\tau^*(t^*)$ increases with EIE < 0 and comes closer to the $\tau = 5$ line. This effect will be larger with a more negative EIE effect. To summarize, for most commodity policies, *economic interaction effects (EIEs) reduce deadweight costs per unit of transfer and increase the political optimal research investment levels.*

The Impact of Endowment Income Differences

In many countries with economic development, other forces affect relative rural-urban incomes in addition to the levels of PARI such as farm structure, climate, land endowments and the like. We depict these other factors as "endowment income" differentials reflected in y^A_e/y^B_e. Endowment income differentials affect the politically optimal policy combination because they change the relative welfare effects of the policies. Swinnen and de Gorter (1993) show that when one sector's income falls below the other sector's income, an endogenous redistribution scheme to partially compensate this exogenously induced income gap is politically optimal. This result still holds in a two-policy framework: $\partial t^*/\partial y^A_e < 0$, independent of the PARI income distribution effects.[11] The intuition is as follows: if agriculture's endowment income falls, then farmers will experience a larger marginal change in utility induced by a given transfer t. Consequently, farmers' per capita political reaction will be

studies.

[10] The opposite will hold when EIE > 0, which can occur under the combination of a pivotal research induced supply shift and a very distortionary commodity policy.

[11] A proof can be obtained from the authors.

larger than that of an individual in sector B. Politicians can increase total support by redistributing income to the sector that experiences a decrease in relative endowment income. The reduction is support from the high income sector is more than offset by the gain in support from the lower per capita income sector.

The net transfer t* will now depend on the combination of both income differences (endowment and research induced) which may either reinforce or offset one another. For example, figure 4 shows that redistribution to agriculture (t*) still declines with the share of agriculture in research benefits (β^A) increasing, but that the level of redistribution is affected by the relative income level as well. An increase in β^A will require less subsidies for agriculture (or more taxation to compensate industry). With $y^A_e = y^B_e$, the benefits share at which t* = 0 is, of course, when $\beta^A = \beta^B$. But with agriculture having 40% higher income, taxation of agriculture starts when agriculture gets more than 30% of the research benefits.

Changes in relative endowment incomes will also affect the politically optimal PARI level. More specifically, *a lower endowment income for a group will increase (decrease) research expenditures if the group benefits more (less) from research.* The sign of $\partial\tau^*/\partial y^A_e$ depends on the distribution of research benefits between agriculture and the rest of the economy. If agriculture benefits less than the rest of the economy from research investment ($\beta^A < 50\%$), then there is a positive impact of an increase in farmers' endowment income on equilibrium research investment τ^*: $\partial\tau^*/\partial y^A_e > 0$ with $\beta^A < \beta^B$ (and vice versa). This is reflected in the upward shift of the $\tau^*(t^*)$ curve in figure 5 for $\beta^A < 50\%$ with y^A_e/y^B_e increasing with 40% (i.e. from 1.0 to 1.4). The intuition behind this result is that when the research benefits are distributed unequal and when income transfers through commodity policies induce deadweight costs, the government will also use the research investment policy for redistributive purposes. If industry benefits more from research than agriculture, the government will compensate industry for a relative decrease in their endowment incomes by a combination of increasing research expenditures and by increasing transfers to them. Because research benefits industry relative more, politicians find it convenient to use this (non-distortionary) policy for compensating exogenous changes in income. Hence, politically optimal research investment will increase in this case. This may result in the politically optimal research investment being higher than the social optimal (i.e. "overinvestment"). Figure 5 illustrates this case: with $\beta^A = 40\%$ and agriculture's endowment income 40% higher, politically optimal research investment equals 5.12, which is more than the social optimum (= 5).

This overinvestment in research for compensation occurs up to the point when the endowment income difference and the research benefits distribution effect exactly offset one another. In the case when $y^A_e = 14$ and $y^B_e = 10$, figures 4 and 5 show that this offsetting point occurs when $\beta^A = 30\%$. At this point there is no redistribution ($t^* = 0$). When agriculture gets even less of the benefits ($\beta^A <$ 30%), the political demand for compensation becomes stronger than the (opposite) demand for compensating the endowment income effects. As a result, agriculture is subsidized ($t^* > 0$) and we observe underinvestment again ($\tau^* < \tau^m = 5$).

While this overinvestment is limited to the $30\% < \beta^A < 50\%$ interval, the politically optimal PARI with $y^A_e/y^B_e = 1.4$ is higher than when endowment incomes are equal ($y^A_e/y^B_e = 1.0$) as long as $\beta^A < 50\%$. The opposite happens when farmers have higher endowment incomes and benefit more from research. In this case, industry demands compensation for both lower endowment incomes and less research benefits. The endogenous increase in taxation of agriculture and the associated deadweight costs, reduce the politically optimal research investment. This is illustrated in figure 5, which shows how the $\tau^*(y^A_e/y^B_e = 1.4)$-curve is higher than the $\tau^*(y^A_e/y^B_e = 1.0)$-curve for $\beta^A > 50\%$.

In summary, when the endowment and research income distributional effects reinforce one another, they cause a decline in political optimal PARI τ^* and an increase in the optimal transfer t^*. When the two effects mitigate one another, τ^* increases and t^* declines.[12] Whether τ^* is larger or smaller than τ^m and the sign of t^* depends on the relative importance of both effects, itself determined by other exogenous factors, including the structure of the economy.

Implications for the Endogenous Growth Literature

Our results can contribute to the understanding of several results in the growing literature on endogenous policy that emphasize links between income distribution and economic growth (Persson and Tabellini 1992, 1994; Alesina and Perotti; and Alesina and Rodrik). These studies argue that inequality harms growth because it induces redistribution which in turn reduces growth promoting investments by the private sector. Although empirical analysis confirms the strong link between equality and growth, the specific role of policies are not analyzed. Both Persson and Tabellini (1992) and Alesina and Perotti emphasize the need for future research to identify more explicitly the link between income distribution and policy and the link between policy and growth.

Our paper focuses explicitly on policy choices in an endogenous policy framework and includes both policies of redistribution and public good investments. We have derived how inequality affects the political equilibrium level of redistribution and public good investment. Assuming that more redistribution reduces aggregate economic growth through its inherent deadweight costs while public good investments stimulates growth, our model provides an explanation for 3 key observations

[12] In addition, it can be shown that $\partial\tau^*/\partial\beta^A < 0$ iff $y^B_e \le y^A_e$ and $\beta^B \le \beta^A$; and that $\partial\tau^*/\partial\beta^A > 0$ iff $y^B_e \ge y^A_e$ and $\beta^B \ge \beta^A$.

forwarded in Persson and Tabellini (1994): (1) a strong negative relation between inequality and growth, (2) a weak positive relation between inequality and redistribution, and (3) a weak negative effect of redistribution on growth.

Our model shows how redistribution is induced by inequality. However, the existence of public good investments as a second policy complicates the relationship as to how inequality affects redistribution. Public good investments are an additional (endogenous) source of inequality, even though growth is induced. An increase in either exogenous (endowment) or endogenous inequality generates a political need for redistribution which results in more deadweight costs. Therefore, public good investments and redistribution will depend on both endowment income inequality and on the distributional effects of the public good investment. Let us consider both possible cases in order to show the effects of inequality on endogenous policy choices and on growth (see figure 6 for a schematic summary of our arguments below)

Case 1: if the public good investment reduces inequality (offsets endowment income inequality), then public good investments are higher, and redistribution is lower than otherwise. In this case, public good investments reduce the need for redistribution while the income distribution effects of the public good induces governments to increase investments in public goods. We therefore expect a strong positive relationship between post-policy (observed) equality and growth (as observed in Persson and Tabellini, (1994).

Case 2: if the public good investment increases inequality (exacerbates endowment inequality), then public good investments are lower, and redistribution is higher than otherwise. In this case, inequality increases with public good investments, thereby increasing redistribution and hence tempering growth.

Public good investments are lower than otherwise, generating a negative relationship between inequality (both pre-policy and post-policy inequality) and growth.

Our analysis provides a qualified explanation for the endogenous policy literature's major proposition on the strong negative relationship between inequality and growth. In case 1, inequality in pre-policy endowment incomes can be offset by the distributional effects of public good investments such that there is no negative relationship between pre-policy inequality and growth. Pre-policy or exogenous inequality is offset by public good investments such that one gets a strong positive relationship between post-policy equality and growth. On the other hand, both pre-policy and post-policy inequality are negatively related to growth in case 2.

It is important to distinguish between exogenous endowment inequality from the endogenous income distributional effects of public good investments. Public good investments are an integral part of the political decision making in our model with important interactions with redistributive policy. In addition to the income distribution effects, politicians balance the political benefits of increasing the social pie with public good investments with the deadweight costs due to redistribution. Redistribution can moderate inequality induced by public good investments, thereby allowing for more public good investments (provided the interaction effects between the two policies in increasing deadweight costs are not too severe; see de Gorter, Nielson and Rausser; and Swinnen and de Gorter, 1995b). We argue that the strong positive relationship between equality and growth reported by the endogenous policy literature includes the effect of both redistribution and public good investment policies. Redistributive policy reduces inequality due to differentials in either endowment incomes or in distributional effects of public good investments, thereby inducing governments to provide more public goods. It is even possible that the income distribution effects of public good investments offsets inequality in endowment incomes, thereby reducing the need for redistribution. In our political model, the costs of redistribution (to reduce inequality in either endowment incomes or differential income effects of public good investments) is balanced by politicians against the economic gains of the now more politically acceptable public good investments.[13]

Furthermore, our model provides an explanation for why Persson and Tabellini (1994) find a weak negative effect of redistribution on growth (see their discussion of Table 8). If inequality decreases with the public good investment (case 1), then the growth-promoting public good investment generates a decrease in redistribution. This is consistent with a negative association between growth and redistribution. However, our explanation as to their *weak* negative effect of redistribution on growth is that when inequality increases with public good investments (case 2) redistribution increases to moderate inequality, allowing governments to take advantage of growth generated by the public good investment. This reverse effect of growth on redistribution (induced by the public good's effect on inequality and hence on redistribution) may explain why Persson and Tabellini (1994) obtain a *weak* negative effect of redistribution on growth over the entire dataset (which covers both cases presumably). Despite the growth reducing increase in redistribution due to the public good, the public good investment itself has a direct positive effect on growth. Governments still make public good investments even if it exacerbates inequality (although investments are lower than otherwise) because redistribution is a policy option to partially offset political opposition.

Finally, the weak positive effect inequality on redistribution concluded by Persson and Tabellini (1994) may be explained by the fact that they do not directly measure either the pre-policy endowment inequality or the income distributional effects of public good investments. Instead, they have only one

[13] This is analogous to the argument made by Alesina and Perotti that redistributive policies targeted to reduce inequality may increase economic growth: "fiscal transfers may be beneficial if the fiscal burden of the transfers is compensated by the gain in social harmony" (p. 2). In our paper, government's gain political support by using redistributive policy, allowing for more public good investments.

policy instrument and evaluate aggregate post-policy (or observed) inequality. This may explain why they find a weak positive effect of inequality on redistribution.

Conclusions

Stylized facts on government policies in agriculture are (a) that industrial countries subsidize agriculture, while developing countries tax farmers, with negative efficiency effects on domestic and international markets; and (b) that underinvestment in public agricultural research investment (PARI) prevails in both developing and industrial countries, despite evidence that PARI is an important source of productivity growth in agriculture and of social income in general.

This paper presents an explanation for these stylized facts. We show that a political support maximizing government will invest less than the social optimum when research benefits are unequal. Furthermore, due to political interaction effects between both policies, governments will tax agriculture when agriculture gets most of the benefits from research and subsidizes agriculture when agriculture gets only a small share of the benefits from research. Conversely, this endogenous redistribution induces a reduction in opposition to the reforms, which increases political optimal level of PARI. However in the presence of deadweight costs, underinvestment will remain. Similarly, changes in deadweight costs per unit of transfer caused by the research policy will only change the extent of underinvestment.

Combining these conclusions with the insights that economic development changes the relative benefits from agricultural research, and more specifically that agriculture benefits increasingly less from research with economic growth, this model provides an explanation of why agriculture is increasingly subsidized when the economy grows and that underinvestment is observed in both developing and industrial countries.

In the last section we show how other (non-policy) sources of income inequality affect the political outcome. We conclude that when both sources of inequality are in the same direction, our conclusions are reinforced. When the sources of inequality are offsetting, the results may change and that, in some cases, overinvestment may result as political support maximizing governments are induced to use PARI for distributive purposes as well. Finally, we offer several insights from our model which may explain observations from the emerging literature on the political economy of endogenous growth.

References

Alesina, A. and R. Perotti. "Income Distribution, Political Instability, and Investment", Institute for Policy Reform, Paper IPR53, 1992.

Alesina, A. and D. Rodrik. "Distributive Politics and Economic Growth", NBER Working Paper 3668 (Revised February 1993).

Alston, J. M., G. W. Norton, and P. B. Pardey. *Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting*. Ithaca: Cornell University Press, 1995.

Alston, J. M., G. W. Edwards and J. W. Freebairn. "Market Distortions and Benefits from Research", *Amer. J. Agr. Econ.* 70 (1988):281-288.

Anderson K. and Y. Hayami. *The Political Economy of Agricultural Protection*. Winchester: Allen & Unwin Inc., 1986.

Binswanger, H., Y. Mundlak, M. Yang and A. Bowers. *Estimation of Aggregate Agricultural Supply Response*. World Bank mimeo, Washington, D.C., 1985.

Chambers, R. G. and R. Lopez. "Public Investment and Real-Price Supports", *Journal of Public Economics*, 52(1993):73-82.

Cochrane, W.W. *The City Man's Guide to the Farm Problem*. Minneapolis, MN: University of Minnesota Press, 1965.

Coughlin, P. J. *Probabilistic Voting Theory*, Cambridge: Cambridge University Press, 1992.

de Gorter, H., D.J. Nielson and G.C. Rausser. "Productive and Predatory Public Policies", *Amer. J. of Agr. Econ.*, 74(1992): 27-37.

de Gorter, H. and Y. Tsur. "Explaining Price Policy Bias in Agriculture: The Calculus of Support-Maximizing Politicians", *Amer. J. of Agr. Econ.*, 73(1991):1244-1254.

de Gorter, H. and D. Zilberman, "On the Political Economy of Public Good inputs in Agriculture", *Amer. J. Agr. Econ.*, 72(1990): 131-37.

de Janvry, Alain. "Why Do Governments Do What They Do: The Case of Food Price Policy," Paper presented at the Conference on the Role of Markets in the World Food Economy, Minneapolis, October 14-16, 1982.

Downs, A., *An Economic Theory of Democracy*, New York, Harper and Row Publishers, 1957.

Edwards, G.W. and J. W. Freebairn. “The Gains from Research into Tradable Commodities”, *American Journal of Agricultural Economics*, 66(1984):41-49.

Foster, W.E. and Rausser, G.C. “Price-distorting Compensation Serving the Consumer and Taxpayer Interest” *Public Choice*, 77(1993): 275-291.

Fox, G.C. “Is the United States Really Underinvesting in Agricultural Research?” *American Journal of Agricultural Economics* ,67(1985):806-12.

Gardner, B.L. *The Economics of Agricultural Policies.* New York, Macmillan Publishing Co., 1987.

Hillman, A.L., "Declining Industries and Political-Support Protectionist Motives", *Amer. Econ. Rev.*, 72(1982): 1180-1187.

Huffman, W.E. and R.E. Evenson. *Science for Agriculture: A Long Term Perspective.* Ames, IA: Iowa State University Press, 1993.

__________. "Contributions of Public and Private Science and Technology to U.S. Agricultural Productivity", *Amer. J. Agr. Econ.* 74(1992):751-56.

Johnson, D. Gale. *World Agriculture in Disarray.* 2d ed. London: Macmillan, 1991.

Krueger, A.O., M. Schiff and A. Valdes. "Agricultural Incentives in Developing Countries." *World Bank Econ. Rev.* 2(1988):255-272.

Lindert, P.H. "Historical Patterns of Agricultural Policy", in P. Timmer (ed.) *Agriculture and the State: Growth, Employment and Poverty in Developing Countries*, Cornell U. Press 1992.

Mayer, W. and R. Riezman, 1987, “Endogenous Choice of Trade Policy Instruments”, *Journal of Inter-national Economics*, 23 (3-4):337-381.

Mueller, D.C., *Public Choice II*, New York, Cambridge University Press, 1989.

Murphy, J. A., W. H. Furtan and A. Schmitz. “The Gains from Agricultural Research under Distorted Trade”, *Journal of Public Economics*, 51(1993):161-172.

Organization for Economic Cooperation and Development (OECD). *National Policies and Agricultural Trade*, 8 vols., Paris, 1987.

Persson, T. and G. Tabellini, 1992, "Growth, Distribution and Politics", *Eur. Econ. Rev.*, 36(1992):593-602.

__________, 1994, “Is Inequality Harmful for Growth?”, *Amer. Econ. Rev.*, 84(3):600-621.

Rausser, G.C. "Predatory versus Productive Government: The Case of U.S. Agricultural Policies" *J. Econ. Persp.* 6(1992):133-158.

Ruttan, V.W. *Agricultural Research Policy*, Minneapolis: University of Minnesota Press, 1982.

Schmitz, A. and D. Seckler. "Mechanized Agriculture and Social Welfare: The Case of the Tomato Harvester". American Journal of Agricultural Economics, 52(1970):569-577.

Schultz, T.W. *The Economic Organization of Agriculture*. New York: McGraw Hill, 1953.

_________. *Distortions of Agricultural Incentives*. Bloomington: Indiana University Press, 1978.

Stiglitz, J. "Incentives, Organizational Structures and Contractual Choice in the Reform of Socialist Agriculture" in Braverman, Brooks and Csaki (eds.), *The Agricultural Transition in Central and Eastern Europe and the Former USSR*, Washington, D.C.: The World Bank, 1993.

Sumner, Daniel A. *Agricultural Policy Reform in the United States*, Washington, D.C., The AEI Press, 1995.

Swinnen, J. "A Positive Theory of Agricultural Protection", *Amer. J. Agr. Econ.* 76(1994):1-14.

Swinnen, J. and H. de Gorter, 1993, "Why Small Groups and Low Income Sectors Obtain Subsidies: The 'Altruistic' Side of a 'Self-Interested' Government", *Economics and Politics* 5(1993):285-293.

Swinnen, J. and H. de Gorter, 1995a, "Inequality and the Politics of Redistribution and Public Good Investments" Working Paper 95-12, Department of Agricultural, Managerial and Resource Economics, Cornell University, Ithaca NY.

Swinnen, J. and H. de Gorter, 1995b, "Endogenous Commodity Policies and the Social Benefits from Public Research Expenditures" Working Paper 95-15, Department of Agricultural, Managerial and Resource Economics, Cornell University, Ithaca NY.

Tyers, R. and K. Anderson. *Distortions in World Food Markets*. Cambridge: Cambridge University Press for the Trade Policy Research Center, 1992.

United States Department of Agriculture (USDA), <u>Agricultural Research and Development: Public and Private Investments Under Alternative Markets and Institutions</u> Economic Research Service, Natural Resources and Environment Division, Staff Paper Number AGES-9517, August, 1995.

World Bank. *World Development Report, 1986*. New York: Oxford University Press for the World Bank, 1986.

APPENDIX A.1

Proof of Result 1

To show (with $y^A_e = y^B_e$ and $t = 0$):
(a) $\tau^* = \tau^m$ for $\beta^A = \beta^B$,
(b) $\tau^* < \tau^m$ for $\beta^A \neq \beta^B$,
(c) $\partial\tau^*/\partial\beta^A > 0$ for $\beta^A < \beta^B$ and $\partial\tau^*/\partial\beta^A < 0$ for $\beta^A > \beta^B$.

Proof:
(a) with t=0 and $\beta^A = \beta^B$, $U_y^A(\tau^*)=U_y^B(\tau^*)$ and $S_v^A(\tau^*)=S_v^B(\tau^*)$, implying that $y_\tau^A(\tau^*)+y_\tau^B(\tau^*)=1$. Using condition (3) this implies that $\tau^* = \tau^m$. Q.E.D.

(b) Define $k(\tau)=(S_v^A(\tau)U_y^A(\tau))/(S_v^B(\tau)U_y^B(\tau))$ and the right hand side as $z(\tau)= - y_\tau^B(\tau)/y_\tau^A(\tau)$. It follows that $z(\tau^m)=1$ always, but $k(\tau^m)=1$ only iff $\beta^A = \beta^B$. Furthermore, with $\beta^A > \beta^B$: $k(\tau^m)<1$, $\partial k(\tau)/\partial\tau <0$ and $\partial z(\tau)/\partial\tau >0$ (and vice versa for $\beta^A < \beta^B$). This implies that $\tau^* < \tau^m$ for $\beta^A \neq \beta^B$. Q.E.D.

(c) Denote equilibrium condition (8) as $G(\tau^*,\beta^i) \equiv 0$. Then we can derive
$\partial\tau^*/\partial\beta^A = - G_\beta/G_\tau$
where
$G_\beta = (H^A y_\tau^A - H^B y_\tau^B) f(\tau) + \theta_\tau$
$G_\tau = H^A (y_\tau^A)^2 - H^B (y_\tau^B)^2 + \theta_{\tau\tau}$
$\theta_\tau = (S_v^A U_y^A - S_v^B U_y^B) f_\tau(\tau)$
$\theta_{\tau\tau} = (S_v^A U_y^A \beta^A - S_v^B U_y^B \beta^B) f_{\tau\tau}(\tau)$
$H^i = S_v^i (U_y^i)^2 + (S_v^i U_{yy}^i)$

Given the concavity assumptions, it follows that $H^i < 0$ and that $\theta_{\tau\tau} < 0$, which implies that $G_\tau < 0$ always. Furthermore, $\theta_\tau <,=,> 0$ and $G_\beta >,=,< 0$ for $\beta^A <,=,> \beta^B$. Combining this yields that $\partial\tau^*/\partial\beta^A >,=,< 0$ for $\beta^A <,=,> \beta^B$. Q.E.D.

Proof of Result 2

To show (with $y^A_e = y^B_e$): $\partial t^*/\partial\beta^A < 0$.

Proof:
Now consider the joint optimization of t^* and τ^*. To formally derive the effects of changes in key structural variables on the policy combination, let
$R\,(t^*,\tau^*, \beta^i, y^i_e, x) \equiv 0$
$G\,(t^*,\tau^*, \beta^i, y^i_e, x) \equiv 0$
represent conditions (7) and (8), respectively.

Vector x represents a set of additional exogenous variables that affect the equilibrium policies. From this system of equations, we can derive the impact of these exogenous variables on both t* and τ*. Applying Cramer's rule and the implicit function rule,it follows that

$\partial t^*/\partial\beta^A = -(R_\beta G_\tau - R_\tau G_\beta) / (R_t G_\tau - R_\tau G_t)$

where

$R_y = \partial R/\partial y^A_e$, $R_t = \partial R/\partial t^*$, $R_\tau = \partial R/\partial \tau^*$, $G_y = \partial G/\partial y^A_e$, $G_t = \partial G/\partial t^*$, $G_\tau = \partial G/\partial \tau^*$,

$R_\beta = (H^A + H^B(1 + c_t))\, f(_\tau) < 0$,

$G_\beta = (H^A y^A_\tau - H^B y^B_\tau)\, f(_\tau) + \theta_\tau$,

with $G_\beta < 0$ for $t^* < 0$ and $\beta^A > \beta^B$ and $G_\beta > 0$ for $t^* > 0$ and $\beta^A < \beta^B$.

Define denominator D = $R_t G_\tau - R_\tau G_t$, which can be rewritten as $D = \theta_{\tau\tau} R_t - \theta_{tt} G_\tau + 2\theta_{t\tau} R_\tau$

where

$$R_t = H^A + H^B(1 + C_t)^2 - \theta_{tt} \qquad < 0$$

$$G_\tau = H^A (y^A_\tau)^2 + H^B (y^B_\tau)^2 + \theta_{\tau\tau} \qquad < 0$$

$$R_\tau = H^A y^A_\tau - H^B(1 + c_t) y^B_\tau - \theta_{t\tau}$$

$$\theta_{\tau\tau} = (S^A_v U^A_y \beta^A + S^B_v U^B_y \beta^B) f_{\tau\tau} \qquad < 0$$

$$\theta_{tt} = S^B_v U^B_y c_{tt} \qquad > 0$$

$$\theta_{t\tau} = S^B_v U^B_y c_{t\tau}$$

and $\theta_{t\tau} >,=,< 0$ for $c_{t\tau} >,=,< 0$.

Further, $R_\tau > 0$ for $\beta^A < \beta^B$ and $c_{t\tau} \le 0$, and $R_\tau < 0$ for $\beta^A > \beta^B$ and $c_{t\tau} \ge 0$.

Denominator D is affected by three distinct factors.

The first term ($\theta_\tau R_t$) reflects the PIE, i.e. how changes in one government policy (t or ι) affect the endogenous "weights" of the two sectors in the governments' derived preference function, and thus the political equilibrium of both policies. This term is always positive, given our assumptions and $R_t < 0$.

The second term ($-\theta_{tt} G_\tau$) represents the deadweight costs of the transfer policy (t). This term is also positive (with $G_\tau < 0$) unless there are no deadweight costs ($C_{tt} = 0$) in which case the term becomes zero.

The last term ($2\theta_{t\tau} R_\tau$) represents the EIE: with $c_{\tau t} = 0$ it disappears and $D > 0$. If EIEs are present, the sign depends both on the sign of $c_{\tau t}$ and on the distribution of research benefits: e.g. the term will be negative if $c_{\tau t} < 0$ and $\beta^A < \beta^B$. In general, it tends to mitigate the first two terms, but in principle it could enforce them as well. This might be possible with a very distortive intervention instrument in industrial countries ($c_{t\tau} > 0$ and $\beta^A < \beta^B$). In fact, one could argue that the combinations which make the third term positive are less probable combinations: a very distortive instrument ($c_{\tau t} > 0$) in LDCs ($\beta^A > \beta^B$); or a less distortive instrument ($c_{\tau t} < 0$) in rich countries ($\beta^A < \beta^B$).

Define numerator $N = R_\beta G_\tau - R_\tau G_\beta$, which can be rewritten as $N = -\theta_{\tau\tau} R_\beta + \theta_\tau R_\tau - \theta_{\tau t} G_\beta$
where
$\theta_\tau = (S^A{}_V U^A{}_y - S^B{}_V U^B{}_y) f_\tau(\tau)$
and $\theta_\tau = 0$ when $c(.) = 0$, and $\theta_\tau >, =, < 0$ for $t^* >, =, < 0$ when $c(t) > 0$.

Without deadweight costs, both θ_τ and $\theta_{\tau t}$ are zero, which implies that $\partial t^* / \partial \beta^A = -R_\beta / R_t < 0$ with $R_\beta < 0$ and $R_t < 0$.

With deadweight costs, the effect becomes more complicated as both the numerator and denominator have additional terms, all of which are conditional on the structure of research benefits and the level of subsidization. With deadweight costs present, $\theta\tau$ depends on the net transfer (reflecting the relative impact of the endowment income difference and the differential research impact): $\theta\tau >,=,< 0$ for $t^* >,=,< 0$. Further, $R\tau >,= < 0$ for $\beta^A <,=, > \beta^A$. Using these results, it follows that, *without EIEs*, $\partial t^* / \partial \beta^A < 0$ for $\beta^A \geq \beta^B$ and $t^* > 0$, and, for $\beta^A \leq \beta^B$ and $t^* \leq 0$. With $y^A{}_e = y^B{}_e$ these combinations cover the whole domain. Therefore: $\partial t^* / \partial \beta^A < 0$.

With EIEs > 0, $\partial t^* / \partial \beta^A < 0$, because the third term of N enforces the other terms' impact. With EIE < 0, the third term of N mitigates the other terms' impact. The aggregate effect cannot be derived conclusively without imposing specific functional forms on the terms. The simulations in the graphs illustrate the intuitive result that economic interaction effects enforce this when they are positive (EIEs > 0) and mitigate this when they are negative (EIES < 0), but in all our simulations the EIE effect never overtook the DWC effect and the distributional effect, such that $\partial t^* / \partial \beta^A < 0$ for $y^A{}_e = y^B{}_e$ also with EIE < 0 in the simulations.

Proof of Results 3 and 4

<u>To show</u> (with $y^A{}_e = y^B{}_e$): $\tau^*(t=0) \leq \tau^*(t^*) \leq \tau^m$

<u>Proof:</u>
Analogous to Proof 1(b) define $k(t,\tau)=(S_v{}^A(t,\tau)U_y{}^A(t,\tau))/(S_v{}^B(t,\tau)U_y{}^B(t,\tau))$ and $z(\tau) = - y_\tau{}^B(\tau)/y_\tau{}^A(\tau)$. Notice that $z(\tau)$ is unaffected by the transfer t. Independent of the PARI distributional effects, $\partial k(t,\tau)/\partial t < 0$ and we know from Proof 1(b) that $\partial k(t,\tau)/\partial \tau > 0$ for $\beta^A < \beta^B$. In this case that $\beta^A < \beta^B$, this implies that $\tau^*(t=0) \leq \tau^m$ (Result 1) and that a transfers from sector B to A will be induced ($t^*>0$ (Result 2)). With $\partial k(t,\tau)/\partial t$ and $\partial k(t,\tau)/\partial \tau$ as derived above, this implies that $\tau^*(t=0) < \tau^*(t^*)$. But, with $z(\tau^m)=1$, $\tau^*(t^*) = \tau^m$ only if $k(t^*,\tau^*)=1$. This would imply full compensation, i.e. $y^B(t^*,\tau^*) = y^A(t^*,\tau^*)$, implying that $S_v{}^A(t^*,\tau^*) = S_v{}^B(t^*,\tau^*)$ and $U_y{}^A(t^*,\tau^*) = U_y{}^B(t^*,\tau^*)$. However, this can only occur if $c(t^*) = c_t(t^*) = 0$; otherwise: $\tau^*(t^*) < \tau^m$. With more distortionary transfers, $c(t^*)$ and $c_t(t^*)$ will be larger, and hence create a larger gap between $y^B(t^*, \tau^*)$ and $y^A(t^*,\tau^*)$, and thus between $\tau^*(t^*)$ and τ^m. <u>Q.E.D.</u>

Proof of Result 5

To show (with $y^A_e = y^B_e$):
(a) $\tau^*(t^*) = \tau^m$ iff $c(t^*) = c_t(t^*) = 0$;
(b) $\partial\tau^*(t^*)/\partial\beta^A > 0$ for $\beta^A < \beta^B$ (and vice versa).

Proof:
(a) see proof of results 3 and 4.

(b) Analogous to the derivations in the proof of Result 2, we can derive that
$\partial\tau^*(t^*)/\partial\beta^A = -(R_t G_\beta - R_\beta G_t) / D$, which can be rewritten as :
$\partial\tau^*(t^*)/\partial\beta^A = (\theta_{\tau\tau} G_\beta - \theta_\tau R_t - \theta_{\tau t} R_\beta) / D$
where D is the same denominator as in $\partial t^*/\partial\beta^A$ in the proof of Result 2.

Without deadweight costs all these terms are zero ($\theta_{tt} = \theta_\tau = \theta_{\tau t} = 0$) and, thus, $\partial\tau^*/\partial\beta^A = 0$. This implies that, in the absence of deadweight costs, there is no effect of the share of research benefits on the politically optimal research investment τ^*.

With deadweight costs, but without EIEs, the third term ($-\theta_{\tau t} R_\beta$) is still zero, but the first two no longer. This implies that $\partial\tau^*(t^*)/\partial\beta^A = (\theta_{\tau\tau} G_\beta - \theta_\tau R_t) / D$. We showed earlier that denominator D is positive. The sign of the numerator depends on the distribution of the benefits and the level of the transfer t^* (which itself depends on the relative research benefits, given that endowment incomes are equal). With $\beta^A < \beta^B$ and, thus, $t^* > 0$, $G_\beta > 0$ and $\theta_\tau > 0$. This implies, with $\theta_{tt} > 0$ and $R_t < 0$ always, that $\partial\tau^*(t^*)/\partial\beta^A > 0$ for $\beta^A < \beta$. Inversely, with $G_\beta < 0$ and $\theta_\tau < 0$ for $\beta^A > \beta^B$ and $t^* < 0$, it follows that $\partial\tau^*(t^*)/\partial\beta^A < 0$ for $\beta^A > \beta^B$.

As in the proof of Result 2, with EIEs > 0, $\partial\tau^*(t^*)/\partial\beta^A > 0$ for $\beta^A < \beta$, because the third term of the nominator ($-\theta_{\tau t} R_\beta$) enforces the other terms' impact. With EIE < 0, the third term mitigates the other terms' impact. Again, the aggregate effect cannot be derived conclusively without imposing specific functional forms on the terms. The simulations in the graphs illustrate the intuitive result that economic interaction effects enforce this when they are positive (EIEs > 0) and mitigate this when they are negative (EIES < 0), but in all our simulations the EIE effect never overtook the DWC effect and the distributional effect, such that $\partial\tau^*(t^*)/\partial\beta^A > 0$ for $\beta^A < \beta$ with $y^A_e = y^B_e$ also with EIE < 0 in the simulations.

A.2 Simulation Model Details

The following functional forms were used for the simulations of social and politically optimal policies:

$U^i = U(y^i) = 2*y^i - 0.05*(y^i)^2$
$S^i = S(v^i) = 2*v^i - 0.05*(v^i)^2$
$v^i = U^i(t,\tau) - U^i(0,0)$
$f(\tau) = 2*\tau - 0.1*(\tau)^2$
$c(t,\tau) = h * t^2 /[1+f(\tau)^j]$, with h and j varying.

With $h > 0$ and $j = 0$, 1 or 2, $c(t,\tau)$ behaves consistent with the assumptions on the general deadweight cost function in the paper (see section The Model).

Figure 1: Distribution of Research Benefits and Politically Optimal PARI (τ*)

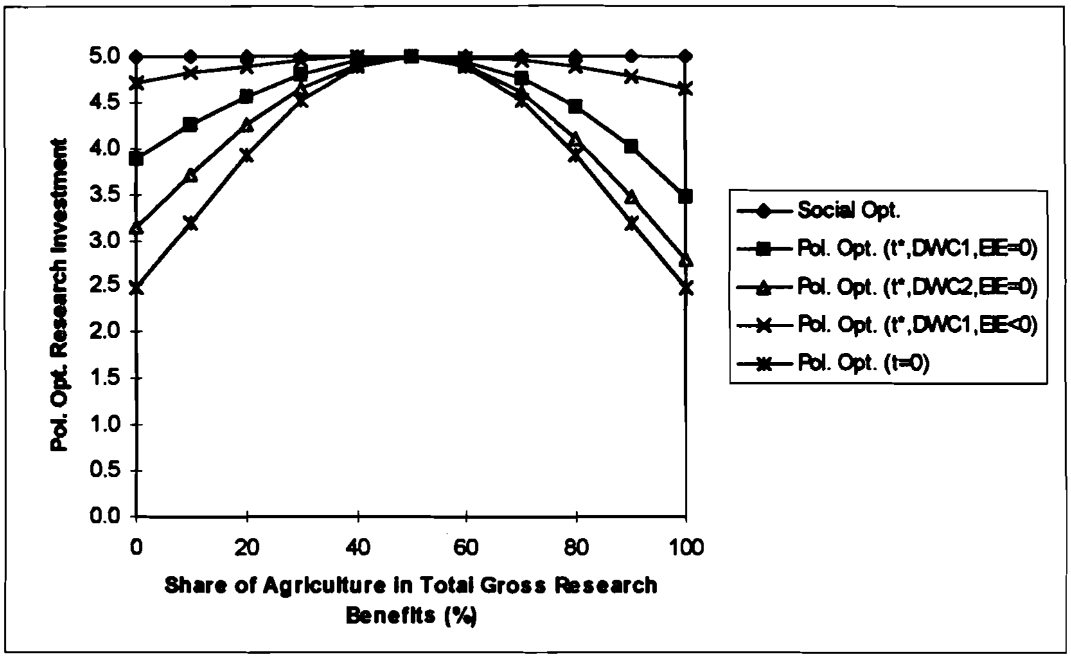


Figure 2: Distribution of Research Benefits and Politically Optimal Transfer (t*)

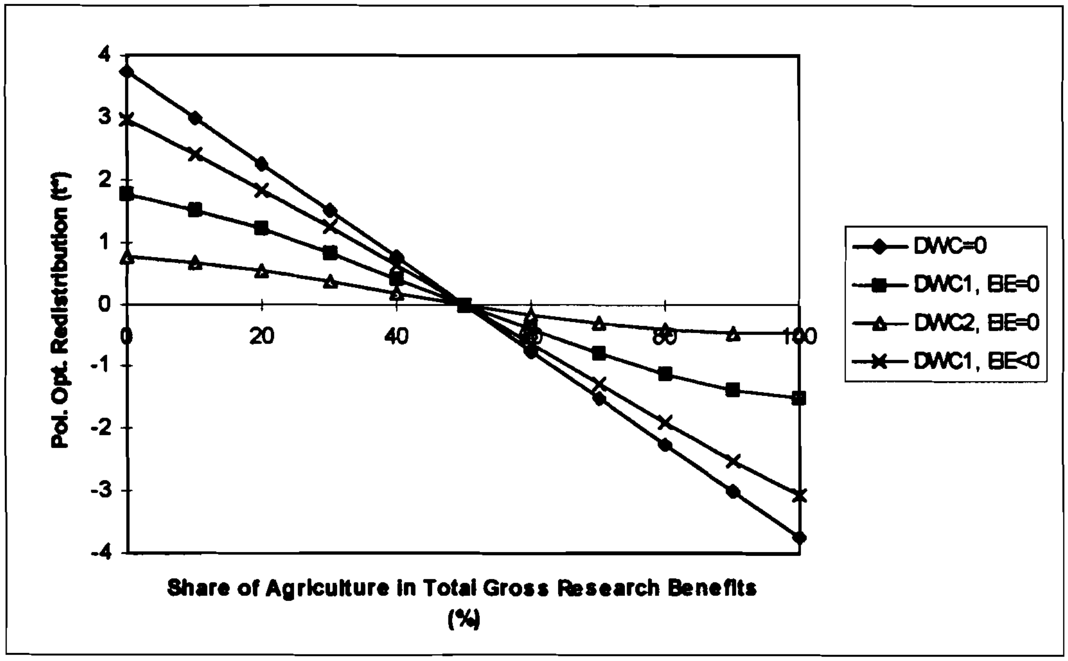


Figure 3: Impact of public investment on deadweight costs of an import tariff

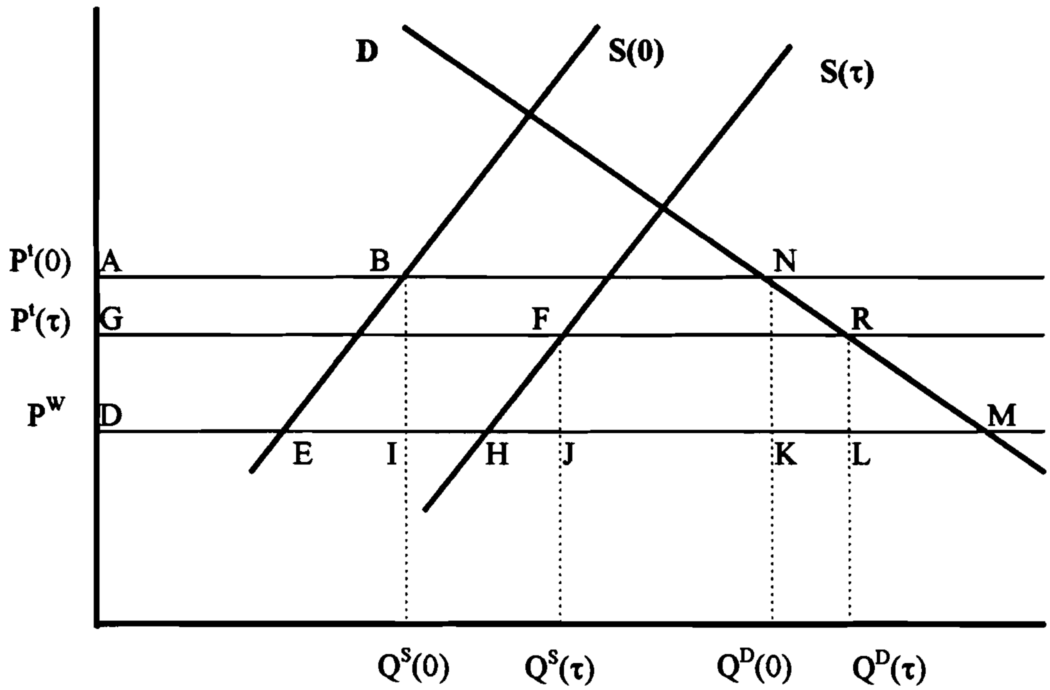


Figure 4: Endowment Incomes, Distribution of Research Benefits and Politically Optimal Transfer (t*)

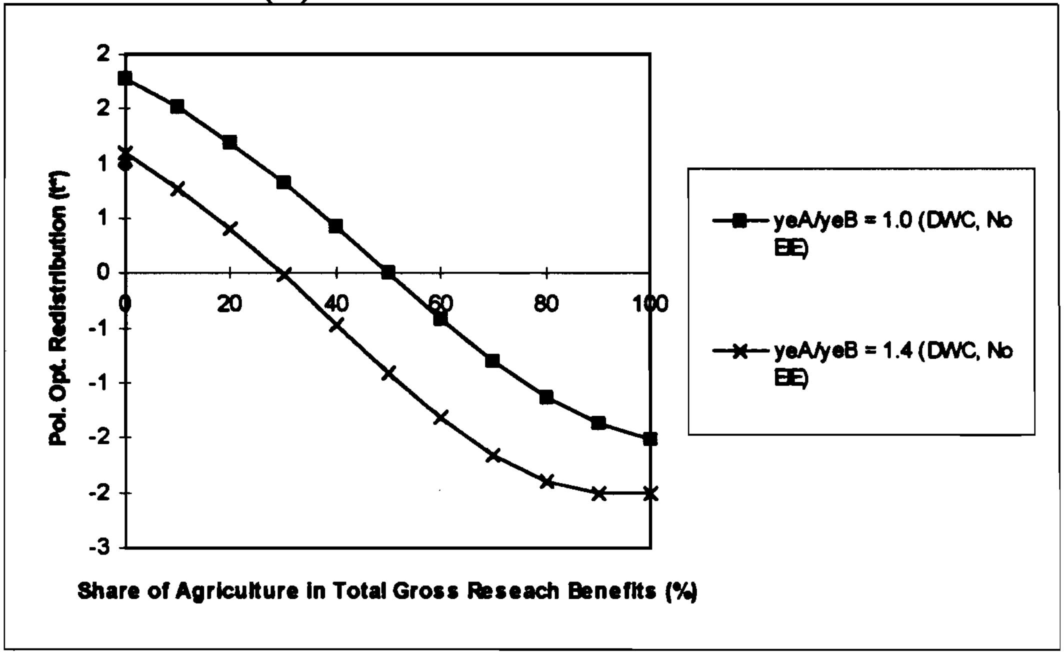


Figure 5: Endowment Incomes, Distribution of Research Benefits and Politically Optimal PARI (τ*)

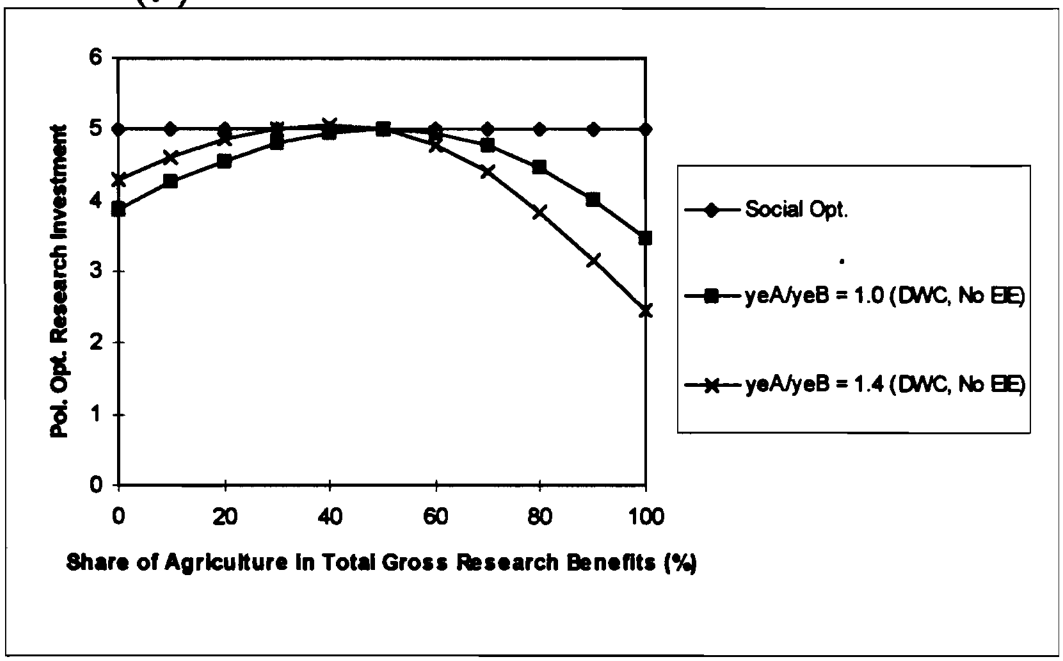
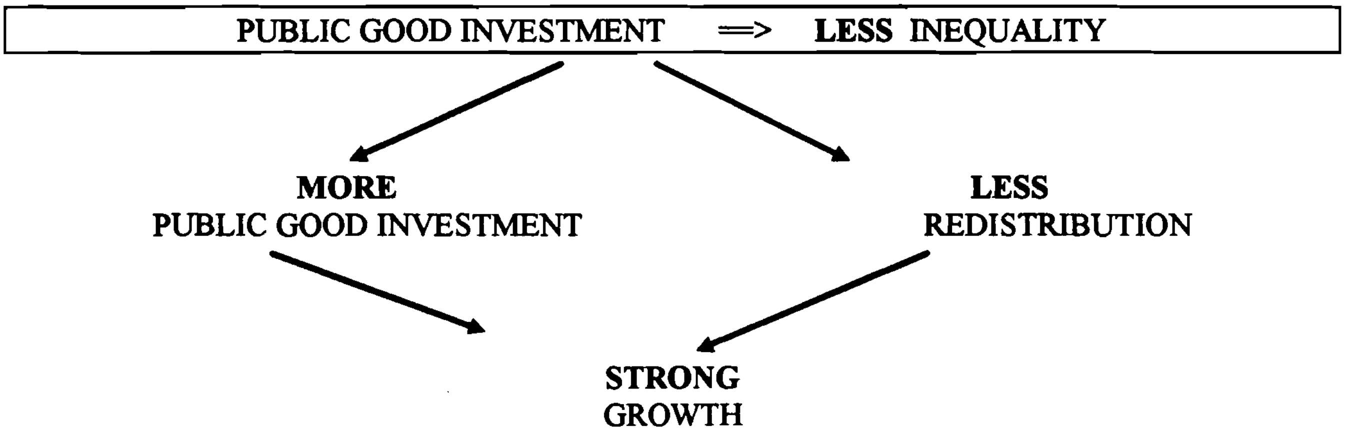
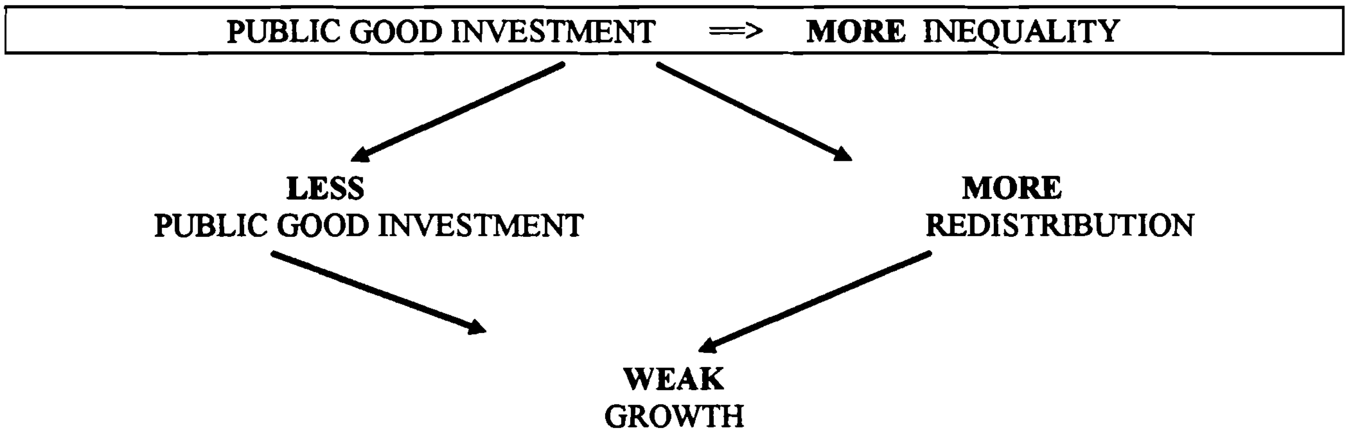


Figure 6: Inequality, public good investment, redistribution and growth

Case 1: Public good investment offsets endowment inequality



Case 2: Public good investment exacerbates endowment inequality



<u>**OTHER A.R.M.E. WORKING PAPERS**</u>

No. 96-12	A Hedonic Approach to Estimating Operation and Maintenance Costs for New York Municipal Water Systems	Todd M. Schmit Richard N. Boisvert
No. 96-13	The Productivity of Dairy Farms Measured by Non-Parametric Malmquist Indices	Loren W. Tauer
No. 96-14	A Unique Measure of the Welfare Effects of Price Support Programs for Corn on Family-Farm Households by Size Distribution	Tebogo B. Seleka Harry de Gorter
No. 96-15	Economies of Size in Water Treatment vs. Diseconomies of Dispersion for Small Public Water Systems	Richard N. Boisvert Todd M. Schmit
No. 96-16	Developing a Demand Revealing Market Criterion for Contingent Valuation Validity Tests	Daniel Rondeau Gregory L. Poe William D. Schulze
No. 96-17	The G-3 Free Trade Agreement: Member Countries' Agricultural Policies and its Agricultural Provisions	Ricardo Arguello Steven Kyle
No. 96-18	The G-3 Free Trade Agreement: A Preliminary Empirical Assessment	Ricardo Arguello Steven Kyle
No. 96-19	Penn State - Cornell Integrated Assessment Model	Eric J. Barron Duane Chapman James F. Kasting Neha Khanna Adam Z. Rose Peter A. Schultz