Agricultural Policies in the Presence of Distorting Taxes

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Abstract

This paper uses analytical and numerical general equilibrium models to assess the efficiency impacts of agricultural policies in a second-best setting with pre-existing distortionary taxes. We analyze production subsidies, production quotas, acreage controls, subsidies for acreage reductions and lump sum transfers to agricultural producers. We find that pre-existing taxes raise the cost of all these policies and by a substantial amount. Under our central estimates this increase in cost is typically at least 100-200 percent.

Two effects underlie these results. First, raising the rates of distortionary taxes to finance subsidy policies leads to additional efficiency losses. Second, policies that raise (lower) the costs of producing agricultural output lead to a reduction (increase) in the economy-wide level of employment. This implies an efficiency loss (gain) in the labor market, which is distorted by taxes. The latter effect is not incorporated in earlier studies. Consequently, previous studies have significantly overstated the costs of production subsidies and understated the costs of production quotas, acreage controls and subsidies for acreage reductions.

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PRESENCE OF DISTORTING TAXES

Ian W. H. Parry[*]

1. INTRODUCTION

Throughout the world, governments continue to intervene substantially in agricultural markets. In developed countries this intervention has traditionally taken the form of policies to increase domestic producer prices, such as production subsidies, production quotas, acreage controls and import restrictions.[1] Very recently, and particularly in the U.S., there has been less reliance on this type of regulation, but at the same time environmental programs--such as subsidies for acreage reduction--have been expanded. Developing countries have tended to subsidize inputs into the agricultural sector, while holding down output prices.

This paper analyzes the gross efficiency costs of some of these policy instruments.[2] We examine a production subsidy, production quota, acreage control, subsidy for acreage reduction (SAR) and a lump sum transfer (LST) to agricultural producers. The crucial point of departure from previous studies is the focus on general equilibrium effects and in particular the implications of pre-existing tax distortions in the labor market. Several analysts have pointed out that--in addition to the efficiency impact within the agricultural sector--raising taxes to finance agricultural subsidy policies leads to an efficiency cost.[3] This is the cost of the added distortion to the labor market caused by, for example, increasing the rate of personal or payroll tax. Parry (1997a) refers to this cost as the *revenue-financing effect*.

However, there is another efficiency consequence of agricultural policies that has not been recognized in the literature.[4] Policies that raise the costs of agricultural production tend to reduce the overall level of employment in the economy. The reduction in employment leads to an efficiency loss, given the wedge between the gross and net wage created by the tax system. This has been termed the *tax-interaction effect* in recent analyses of environmental regulations (Goulder, 1995). The tax-interaction effect raises the costs of the production

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[1] See the survey in Sanderson (1990).

[2] We do not consider potential benefits from the policies, such as enhanced natural habitat from land set-asides.

[3] See Gardner (1983a), Alston and Hurd (1990), and Moschini and Sckokai (1994).

[4] Earlier studies "tack on" the revenue-financing effect to a partial equilibrium model of the agricultural sector. They are not fully general equilibrium models because they do not capture the spillover effects in other distorted markets of the economy resulting from changes in the relative price of agricultural output.

quota, acreage control and SAR. In contrast, it partially offsets the revenue-financing effect from the production subsidy.

We find that pre-existing taxes substantially raise the cost of all the policies examined. In our central case estimates, this increase in cost is typically at least 100-200 percent. Previous studies that have ignored the tax-interaction effect have significantly underestimated the overall costs of production quotas, acreage controls and SARs. Conversely, studies that incorporate the revenue-financing effect but neglect the tax-interaction effect, significantly overstate the costs of production subsidies.

We also find that production quotas are a more cost-effective means of transferring income to agricultural producers than LSTs (for transfers up to 10 percent of agricultural income and given our central parameter values). That is, the efficiency costs of financing LSTs by distortionary taxes outweighs the tax-interaction effect and distortion of the agricultural market under production quotas.[5] In contrast, production subsidies are around 30-60 percent more costly than LSTs. Acreage controls and SARs are at least 200 percent more costly than LSTs.

Our results are consistent with recent studies of the tax-interaction effect in other contexts. Goulder et al. (1997) estimate that pre-existing taxes can raise the costs of modest reductions in sulfur emissions by several hundred percent, when emissions are reduced by (non-auctioned) quotas.[6] Browning (1997) estimated that the costs of monopoly pricing in the economy are several times larger when allowance is made for the impact on compounding tax distortions in the labor market. In each of these cases the economy-wide change in employment is "small." However, the cost per unit reduction in employment is "large" because various taxes combine to drive a substantial wedge between the gross and net wage (see below). This means that the efficiency loss in the labor market can still dominate the partial equilibrium effect of a regulation or other market distortion.[7]

In the next section we present a simple analytical model. This model decomposes the general equilibrium efficiency impacts of a production subsidy and quota, in the presence of a tax on labor income. Section 3 describes an extended version of the model that incorporates land as a factor input and considers additional policy instruments. This model is solved numerically using US data, although it could be applied to other countries. We consider cases in which land is transferable between production sectors and where it is sector-specific. Section 4 presents the empirical results and sensitivity analysis from the numerical model. Section 5 offers conclusions and discusses some caveats to the analysis.

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[5] Thus, the substitution of LSTs for production subsidies, reflected in the 1995 Farm Bill, is still efficiency improving in our analysis.

[6] Parry et al. (1996) find similar results for non-auctioned carbon quotas.

[7] For a diagrammatic exposition see Parry (1997b).

2. THE ANALYTICAL MODEL

In this section we use an analytical model to illustrate qualitatively the efficiency impacts of a subsidy and quota on agricultural production in the presence of a pre-existing tax on labor income.[8]

A. Model Assumptions

We assume a static, representative agent model. The household utility function is:

$$U = U(X, Y, \overline{L} - L) \tag{2.1}$$

X is the consumption of agricultural output and Y is an aggregate of all other consumption. $\overline{L}$ - L is hours of leisure or non-market time, where $\overline{L}$ is the household time endowment and L is labor supply. We normalize the gross wage rate to unity.

X and Y are produced by competitive firms using labor. The marginal product of labor is taken to be constant in both sectors implying supply curves are perfectly elastic (for a given gross wage). The extended model in Section 3 incorporates land as a factor of production and upward sloping supply curves.[9] Choosing units to imply marginal products (and hence producer prices) of unity, the economy's resource constraint is:

$$X + Y = L \tag{2.2}$$

The government has an exogenous spending requirement of G, levies a tax of t on labor income and regulates the agricultural sector. For simplicity, G is assumed to be a lump sum transfer to households.[10] We assume the government budget must balance. Therefore, changes in government revenues resulting from agricultural policies are neutralized by adjusting the rate of labor tax.[11]

Given the above assumptions there are no pre-existing distortions in the agricultural sector, hence policy intervention will necessarily lead to an efficiency loss in this market. There are a variety of alleged benefits from farm programs from the stabilization of commodity prices to food security and the preservation of rural communities. More recently, policies such as the conservation reserve program in the US have been justified on

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[8] The model in this section shares some features of those in Goulder et al. (1997) and Parry (1997a), that were applied in the context of environmental regulations.

[9] However, we do not incorporate capital accumulation in the model. This would require making the model dynamic and allowing for taxes on capital.

[10] Alternatively we could assume that G is a public good.

[11] More generally a production subsidy, for example, could be financed by increasing the budget deficit rather than increasing current taxes. This shifts the necessary tax increase, and implied efficiency loss, to a future period.

environmental grounds. We focus purely on the cost side of these policies and do not attempt to assess potential benefits.[12]

B. Production Subsidy

Suppose a subsidy of s per unit for agricultural production is introduced.[13] The household budget constraint amounts to:

$$(1-s)X + Y = (1-t)L + G \qquad (2.3)$$

This equation says that expenditure on goods equals net of tax labor income plus the government transfer. Households choose X, Y and L to maximize utility (2.1) subject to the budget constraint (2.3). From the resulting first order conditions and (2.3) we obtain the implicit, uncompensated demand and labor supply functions:

$$X = X(s,t); \qquad Y = Y(s,t); \qquad L = L(s,t) \qquad (2.4)$$

Substituting these into (2.1) gives the indirect utility function:

$$V = V(s,t) \qquad (2.5)$$

From Roy's Identity:

$$\frac{\partial V}{\partial s} = \lambda X ; \qquad \frac{\partial V}{\partial t} = -\lambda L \qquad (2.6)$$

where the Lagrange multiplier λ is the marginal utility of income.

The government budget constraint is given by:

$$G + sX = tL \qquad (2.7)$$

that is, government spending on the transfer and the subsidy payment equals labor tax revenue.

We now consider the effect of an incremental revenue-neutral increase in the agricultural subsidy. Totally differentiating (2.7) holding G constant, we can obtain:

$$\frac{dt}{ds} = \frac{X + s\dfrac{dX}{ds} - t\dfrac{\partial L}{\partial s}}{L + t\dfrac{\partial L}{\partial t}} \qquad (2.8)$$

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[12] Gardner (1983b) provides a critical evaluation of these benefits. An alternative explanation for farm programs in developed countries is that they are simply transfers obtained by a politically powerful producer group (see Gardner, 1987).

[13] Traditionally in the US, production subsidies for grains and dairy products in the US have taken the form of deficiency payments. These are a subsidy per unit of output equal the difference between a target price and the prevailing market price. The 1995 Farm Bill replaced these type of per unit subsidies with lump sum payments (these are discussed in Section 4). Other industrial countries continue to use deficiency payments.

where

$$\frac{dX}{ds} = \frac{\partial X}{\partial s} + \frac{\partial X}{\partial t}\frac{dt}{ds} \qquad (2.9)$$

is a total derivative. Equation (2.8) defines the increase in labor tax necessary to maintain budget balance following the increase in subsidy.

We define:

$$M = \frac{-t\dfrac{\partial L}{\partial t}}{L + t\dfrac{\partial L}{\partial t}} \qquad (2.10)$$

This is the (partial equilibrium) efficiency cost from raising an additional dollar of labor tax revenue, or marginal excess burden of taxation. The numerator is the efficiency loss from an incremental increase in t. This is the wedge between the gross wage (equal to the value marginal product of labor) and the net wage (equal to the marginal social cost of labor in terms of foregone leisure time), multiplied by the reduction in labor supply. The denominator is marginal tax revenue (from differentiating tL).

The efficiency effect of the policy change can be obtained by differentiating the indirect utility function (2.5) with respect to s, allowing t to vary. This gives:

$$\frac{dV}{ds} = \frac{\partial V}{\partial s} + \frac{\partial V}{\partial t}\frac{dt}{ds}$$

Substituting from (2.6), (2.8) and (2.10) gives:

$$-\frac{1}{\lambda}\frac{dV}{ds} = \underbrace{s\frac{dX}{ds}}_{d\hat{W}^P} + \underbrace{M\left\{X + s\frac{dX}{ds}\right\}}_{d\hat{W}^R} - \underbrace{(1+M)t\frac{\partial L}{\partial s}}_{d\hat{W}^I} \qquad (2.11)$$

This equation decomposes the general equilibrium welfare loss (in monetary terms) into three components. First dW^P, the efficiency loss in the agricultural market, or *primary efficiency cost*. This is the general equilibrium change in agricultural output, multiplied by the difference between the supply and demand price; that is, the wedge between the social marginal cost and social marginal benefit from X created by the subsidy. Second dW^R, the efficiency cost from financing the increase in subsidy by increasing the labor tax, or *revenue-financing effect*. This equals the product of the marginal excess burden of taxation and the marginal subsidy payment. Third dW^I, the efficiency gain from the positive *tax-interaction effect*. The subsidy reduces the price of agricultural consumption, which reduces the price of goods in general. This increases the real household wage and in turn induces an increase in labor supply. The resulting efficiency gain consists of: (i) the increase in labor supply

multiplied by the tax wedge between the gross and net wage $t\partial L/\partial s$; (ii) the efficiency gain from the resulting increase in labor tax revenue, or M multiplied by $t\partial L/\partial s$.

The tax-interaction effect can be expressed (see Appendix A):

$$dW^I = m\mu X\; ;\qquad m = \frac{h^c_{XL} + h_{LI}}{q_X h^c_{XL} + q_Y h^c_{YL} + h_{LI}} \tag{2.12}$$

h^c_{XL} and h^c_{YL} are the compensated elasticity of demand for X and Y with respect to the household wage or price of leisure; h_{LI} is the income elasticity of labor supply; q_X and q_Y are the shares of X and Y in the value of total output ($q_X + q_Y = 1$). m is a measure of the degree of substitution between agricultural output and leisure, relative to that between aggregate consumption and leisure. Suppose X and Y are equal substitutes for leisure ($h^c_{XL} = h^c_{YL}$), then $m = 1$. In this case the (marginal) revenue-financing effect exactly offsets the (marginal) tax-interaction effect when $s = 0$, but exceeds it when $s > 0$ (comparing dW^R with dW^I). Therefore, for a non-incremental increase in the subsidy there would be a net efficiency loss from interactions with the tax system (in addition to the primary efficiency cost).[14] As discussed below, it is most likely that agriculture is a weaker than average substitute for leisure ($h^c_{XL} < h^c_{YL}$), that is $m < 1$. In this case the (marginal) tax-interaction effect is less than the (marginal) revenue-financing effect at $s = 0$. Thus, this analytical model predicts that the marginal cost curve for increasing agricultural output by a production subsidy will have a *positive* intercept.[15]

C. Production Quota

Suppose instead, that agricultural output is reduced below the free market level by a production quota.[16] We define this quota by a virtual tax t; that is, the wedge it creates between the demand price (equal to $1+t$) and supply price of X (equal to unity). This quota creates rents of $p = tX$ for agricultural producers. We assume that these rents accrue to households, who own firms (the numerical model incorporates the taxation of rent income). Therefore the household budget constraint is

$$(1 + t)X + Y = (1 - t)L + G + p \tag{2.3'}$$

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[14] The reason is that the revenue-neutral subsidy makes the overall tax system less efficient by introducing a distortion in the relative price of consumer goods. If X were a relatively strong substitute for leisure, however, a revenue-neutral subsidy could *reduce* the overall costs of the tax system. These results are familiar from optimal commodity tax models, although these models do not decompose the revenue-financing and tax-interaction effects (see, for example, Sandmo, 1976).

[15] Previous studies that incorporate the revenue-financing effect but neglect the tax-interaction effect overstate the overall cost of a production subsidy to the extent that m is positive.

[16] In the US, the output of tobacco and peanuts is regulated by production quotas. Since our model does not incorporate international trade it cannot analyze import quotas, for example in the case of sugar.

where p is exogenous to households. The household demand and labor supply functions can now be summarized by:

$$X = X(\mathsf{t},t,\mathsf{p}); \qquad Y = Y(\mathsf{t},t,\mathsf{p}); \qquad L = L(\mathsf{t},t,\mathsf{p}) \qquad (2.4')$$

and the indirect utility function is:

$$V = V(\mathsf{t},t,\mathsf{p}) \qquad (2.5')$$

where

$$\frac{\partial V}{\partial \mathsf{t}} = -\mathsf{l}\,X\,; \qquad\qquad \frac{\partial V}{\partial \mathsf{p}} = \mathsf{l} \qquad (2.6')$$

The government budget constraint in this case is:

$$G = tL \qquad (2.7')$$

Again, we consider a revenue-neutral incremental increase in t. Differentiating (2.7′) gives:

$$\frac{dt}{d\mathsf{t}} = -\frac{t\,\dfrac{\partial L^{I}}{\partial \mathsf{t}}}{L + t\,\dfrac{\partial L}{\partial t}} \qquad (2.8')$$

where

$$\frac{\partial L^{I}}{\partial \mathsf{t}} = \frac{\partial L}{\partial \mathsf{t}} + \frac{\partial L}{\partial \mathsf{p}}\frac{d\mathsf{p}}{d\mathsf{t}}$$

"*I*" denotes a coefficient that takes into account the income effect from the increase in rents.[17] Equation (2.8′) is the increase in labor tax necessary to maintain budget balance following the reduction in labor supply caused by increasing the quota.

Totally differentiating (2.5′) with respect to t gives

$$\frac{dV}{d\mathsf{t}} = \frac{\partial V}{\partial \mathsf{t}} + \frac{\partial V}{\partial t}\frac{dt}{d\mathsf{t}} + \frac{\partial V}{\partial \mathsf{p}}\frac{d\mathsf{p}}{d\mathsf{t}}$$

Substituting from (2.6′), (2.6), (2.8′) and (2.10), and noting that $d\mathsf{p}/d\mathsf{t} = X + \mathsf{t}(dX/d\mathsf{t})$, gives:

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[17] This income gain roughly offsets the income loss to consumers from the increase in price of *X* (for modest values of t). Therefore, ¶*L*^{I}/¶s is approximately the income-compensated price coefficient. Similarly, the positive income effect in the case of the production subsidy is roughly offset by the negative income effect from financing the subsidy by raising the labor tax.

$$-\frac{1}{|}\frac{dV}{dt} = t\left(-\frac{dX}{dt}\right) + (1+M)t\left(-\frac{\partial L^{I}}{\partial t}\right) \tag{2.11'}$$

$$\underbrace{\qquad\qquad}_{dW^{P}}\quad\underbrace{\qquad\qquad\qquad}_{dW^{I}}$$

The primary efficiency effect, dW^{P}, is the loss from reducing agricultural output; that is, the reduction in output multiplied by the wedge between the consumer and producer price ($dX/dt < 0$). The second term in (2.11') is the tax-interaction effect. This is now a loss rather than a gain, since the quota policy increases the relative price of consumption goods, reduces the real wage and reduces labor supply. Hence the analytical model predicts that the marginal cost curve from a production-reducing quota will also have a positive intercept.

3. THE NUMERICAL MODEL

We now extend the model of Section 2 to allow for more realism, to consider more agricultural policy instruments and to gauge the empirical significance of pre-existing taxes. The extended model incorporates land as a second input in production. We consider cases where land can be transferred between the agricultural and non-agricultural sectors, and where land is sector-specific. The additional policy instruments we analyze are an acreage control, a subsidy for acreage reduction (SAR) and a lump sum transfer (LST) to farmers. The extended model is solved by numerical simulation rather than analytically.[18] In this section we describe the structure and calibration of the extended model.

A. Model Assumptions[19]

(i) Household Behavior

We assume the following nested structure for the household utility function:

$$U = \left\{ a_{U}C^{r_{U}} + (1-a_{U})(\bar{L}-L)^{r_{U}} \right\}^{1/r_{U}} \tag{3.1a}$$

$$C = \left\{ a_{C}(X-\bar{X})^{r_{C}} + (1-a_{C})Y^{r_{C}} \right\}^{1/r_{C}} \tag{3.1b}$$

where the a's and r's are parameters and C is sub-utility from the consumption of goods. (3.1a) says that households have a CES utility function over (composite) consumption and leisure. r_{U} is related to the elasticity of substitution between consumption and leisure (s_{U}) as follows: $r_{U} = (s_{U}-1)/s_{U}$. Equation (3.1b) says that households have a generalized CES utility function over agricultural consumption and non-agricultural consumption. This generalization

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[18] It is possible to solve the extended model analytically for marginal policy changes. However for the non-marginal policy changes examined below, an analytical model could only provide second order welfare approximations rather than the "exact" solutions of the numerical model.

[19] Unless otherwise indicated, variables are as defined in Section 2.

is to Stone-Geary preferences: households gain utility from agricultural consumption over and above the "subsistence" level $\overline{X}$. r_C is related to the elasticity of substitution between consumption goods (s_C) in the same manner as r_U. The a's are distribution parameters. The preference structure represented by (3.1) allows for a variety of different assumptions about the own price and expenditure elasticity of demand for agricultural output, the labor supply elasticity, the relative degree of substitution between agricultural consumption and leisure and the share of agricultural consumption in total consumption.

Households choose X, Y and L to maximize utility (3.1) subject to the following budget constraint:

$$p_X X + p_Y Y = (1 - t_I)(p_L L + p_K \overline{K}) + (1 - t_R)\rho + G \tag{3.2}$$

where the p's denote market prices gross of any taxes or regulations and the t's are tax rates. This maximization problem generates the demand functions for both goods and the labor supply function (see Appendix B). The main difference between (3.2) and the household budget constraints in Section 2 is that households now receive income from renting out an endowment of land ($\overline{K}$) to firms. For simplicity we assume that land income is taxed at the same rate as labor income.[20] In addition, we assume that the economy-wide supply of land is fixed hence the taxation of land does not generate efficiency losses.[21] Rent income ρ is generated under quantity constraints (production quotas and acreage controls) and we now assume this income is taxed at rate t_R.

(ii) <u>Firm Behavior</u>

We assume that X and Y are produced according to the following CES functions:

$$X = \{a_X (L_X)^{r_X} + (1 - a_X)(K_X)^{r_X}\}^{1/r_X} \tag{3.3a}$$

$$Y = \{a_Y (L_Y)^{r_Y} + (1 - a_Y)(K_Y)^{r_Y}\}^{1/r_Y} \tag{3.3b}$$

L and K are the quantity of labor and land respectively, used in each industry. All these input services are rented from households. The r's are related to the elasticities of substitution in production as before, and the a's are distribution parameters. Firms choose inputs to maximize profits subject to these production functions and taking prices as given. This generates the input demand and output supply functions.

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[20] In the US both sources of income are subject to federal and state income taxation. Labor income is also subject to social security taxation, while land income is subject to property taxes. The overall tax rates on these income sources are approximately similar.

[21] More generally, we could include land in the household utility function, which would allow for some elasticity in the supply of land. I am not aware of any empirical evidence on this elasticity. At least in the short run, however, this elasticity is likely to be very low.

We consider two cases for land mobility between production sectors, which span the range of possibilities. In our "flexible land" case, land can be transferred costlessly between the two sectors like labor; in our "fixed land" case, land is sector-specific and non-transferable. The latter is a more realistic assumption in the short run and is more appropriate for analyzing transitory agricultural policies. However, land is less of a sector-specific factor in the long run and the former assumption may be more appropriate for analyzing more permanent agricultural policies.

Incorporating land generates an upward sloping supply curve for agricultural output and a downward sloping economy-wide demand for labor curve because land and labor are substitutes. This complicates the tax-interaction effect. In the model of Section 2 both these curves are perfectly elastic because the marginal product of labor is constant. This means that changes in the economy-wide level of employment are determined purely by changes in household labor supply. In the extended model, changes in the economy-wide level of employment also depend on changes in the demand for labor by firms.

(iii) Government Policy

The production subsidy and quota analyzed below are the same as in Section 2 except that quota rents are now taxed.[22] The acreage control policy is simply a quota imposed on the quantity of land used in agricultural production (again this generates taxable rents).[23] Under the SAR policy, agricultural producers are paid a subsidy per unit to reduce land input below free market levels. In the flexible land case we assume that all land diverted from agricultural production is absorbed by the non-agricultural sector. In the fixed land case we assume—more realistically—that agricultural land is left idle under the acreage control and SAR policies. We also compare these policies with an LST to agricultural producers that has no direct impact on the agricultural sector, but must be financed by distortionary taxes.[24] The production subsidy, SAR and LST are assumed to have no impact on entry into the agricultural sector; that is, they are only available to incumbent producers.

The government budget constraint is given by:

$$G + S = t_I (p_L L + p_K \overline{K}) + t_R \mathrm{p} \tag{3.4}$$

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[22] Governments have also intervened in agricultural markets by purchasing output in order to create floors under producer prices. This policy would be equivalent in its effects to a production subsidy if government acquisitions were given lump sum to households. In practice these acquisitions have frequently been given away in foreign aid, dumped on international and future domestic markets, or left to waste. Thus the overall cost of this policy equals that of the equivalent production subsidy, plus the opportunity cost of government acquisitions being used for purposes other than being returned to households.

[23] Acreage controls have been used to raise producer prices and limit the budgetary costs of deficiency payments in times of low market prices. Other countries continue to use acreage controls, although the US abandoned them after the 1995 Farm Bill.

[24] The US adopted these types of transfers in 1995, to cushion farm income against the effects of deregulation. The initial plan was to phase them out within 7 years.

This differs from the government budget constraints in Section 2 because of revenue from the taxation of land income and rents (in the case of production quotas and acreage controls). *S* stands for budget outlays on the production subsidy, SAR or LST policies.

(iv)   Equilibrium Conditions

For a given set of preference, production and government parameters the general equilibrium is calculated by finding the vector of goods and factor prices such that: (a) the demand for both goods equals the supply; (b) the demand for labor and land by firms equals the labor time endowment net of leisure, and the land endowment, respectively; (c) the household and government budget constraints are satisfied.[25]

B.   Model Calibration

Roughly speaking, the r parameters are calibrated to existing estimates of the relevant elasticity and the a parameters to observed output and factor ratios. The r parameters are most important for determining the relative costs of different agricultural policies. Here we discuss the parameter values used in the benchmark simulations; the results from alternative parameter values are reported in the sensitivity analysis (Appendix B provides more detail on the calibration procedure). We use US data for calibration purposes.[26]

Empirical evidence overwhelmingly suggests that the demand elasticity (expressed as a positive number) and the expenditure elasticity for agricultural products is less than unity. We choose the goods substitution elasticity s_C to imply an (uncompensated) demand elasticity of 0.4 and $\overline{X}$ to imply an expenditure elasticity of 0.4.[27] The degree of substitution between X and leisure relative to that between Y and leisure equals the ratio of the expenditure elasticities for X and Y (Deaton, 1981). If preferences over goods were homothetic ($\overline{X} = 0$), both expenditure elasticities would be unity and the goods would be equal substitutes for leisure. Instead, because the expenditure elasticity is less than unity, agricultural consumption is a relatively weak substitute for leisure (that is, m < 1 in equation (2.12)).[28]

Another important parameter is the consumption/leisure substitution elasticity s_U. We choose this, along with the labor time endowment, to imply uncompensated and compensated labor supply elasticities of 0.15 and 0.4 respectively. These are typical estimates from the literature, and are meant to capture the effects of changes in the real wage on average hours

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[25] The model is straightforward to solve. We used GAMS with MPSGE.

[26] Roughly speaking, this data is probably representative of most developed countries.

[27] Gardner (1990) assumes demand elasticities of between 0.4 and 1. However these are for internationally traded products and are somewhat higher than appropriate for our closed economy model.

[28] More specifically, when the price of leisure--the household wage--increases, labor supply and labor income increase. If the share of this additional income spent on *X* is less (greater) than the share of *X* in the household budget, then *X* is a weaker (stronger) substitute for leisure than consumption as a whole.

worked, the labor force participation rate and effort on the job.[29] We assume a pre-existing tax rate on labor and land of 40 percent.[30] These parameters imply a marginal excess burden of labor taxation in our model equal to 0.27, which is broadly consistent with other studies (for example Browning, 1987; and Ballard et al., 1985). We assume the rent tax is 20 percent.[31]

The elasticities of substitution in production are both chosen to be unity. This is a standard assumption, and our results are not sensitive to alternative values. Finally, the distribution parameters are chosen to imply that--in the absence of agricultural policies--the share of agricultural output in the total value of output is 3 percent; the share of labor and land earnings in the value of agricultural output are both 50 percent; and the share of labor and land earnings in the value of economy-wide output are 90 percent and 10 percent respectively.[32]

Below, we refer to our benchmark case with the income tax as the "second-best" case. We also consider a "first-best" case in which the pre-existing income tax is set to zero, and any expenditure (revenue) consequences of agricultural policies are neutralized by lump sum transfers from (to) households.[33] The efficiency effects generated in the first-best case correspond to the primary efficiency cost terms defined in equations (2.12) and (2.12′).

4. RESULTS

This section illustrates the empirical significance of pre-existing taxes by comparing the first-best and second-best costs of agricultural policies. We consider the costs of non-incremental policy changes, as opposed to the incremental policy changes examined in Section 2.

In the extended model there are three potential efficiency effects due to interactions with the tax system. These are the tax-interaction and revenue-recycling effects discussed above, and another effect, which we call the *factor-shifting effect*. Policies that reduce agricultural production lead to a shift away from the land-intensive sector (agriculture) to the labor-intensive sector (non-agriculture). This increases the aggregate demand for, and price of, labor relative to land. In turn, this induces a substitution out of leisure and into labor, which produces an efficiency gain by offsetting the distortion from labor taxation. This is the factor-shifting effect. For policies that directly reduce agricultural land the factor-shifting effect is (relatively) stronger, while for policies that increase agricultural production, the factor-shifting effect reduces the aggregate demand for labor relative to land and implies an

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[29] See for example the survey by Russek (1994). We use a slightly higher value for the compensated elasticity since the studies in his survey do not capture effort effects.

[30] Other studies use similar values (for example Lucas, 1990; and Browning, 1987). The sum of federal income, state income, payroll and consumption taxes amounts to around 36 percent of net national product. This average rate is relevant for the labor force participation decision. The marginal tax rate, which affects average hours worked and effort on the job, is higher because of various deductions.

[31] Rent is effectively profits and these are subject to personal income taxation. Since these profits come from the agricultural sector they are not subject to corporate income tax.

[32] These figures were inferred from data in the *Economic Report of the President*.

[33] For this case we re-calibrate parameter values such that the model replicates the rest of our benchmark data.

efficiency loss.[34] Our discussion mainly focuses on the tax-interaction and revenue-financing effects, since, except for the acreage control, they are relatively more important than the factor-shifting effect.

Subsections *A* to *D* examine policies individually. Subsection *E* compares the costs of the policies, with that of the LST, on the basis of how much income is transferred to agricultural producers. The final subsection discusses the sensitivity of the results to alternative parameter values.

A. Production Subsidy

Figure 1 illustrates how interactions with pre-existing taxes affect the marginal cost of increasing agricultural output by a production subsidy. In this figure, and figures 2-4, the solid curves indicate marginal costs in the second-best case when the pre-existing income tax is 40 percent, and the dashed curves indicate marginal costs in a first-best case when the income tax is zero. In addition, "circle" and "triangle" legends indicate cases when land is flexible and fixed respectively. The (marginal) costs are general equilibrium welfare losses expressed as a percentage of initial agricultural revenue. There are several noteworthy features from Figure 1.
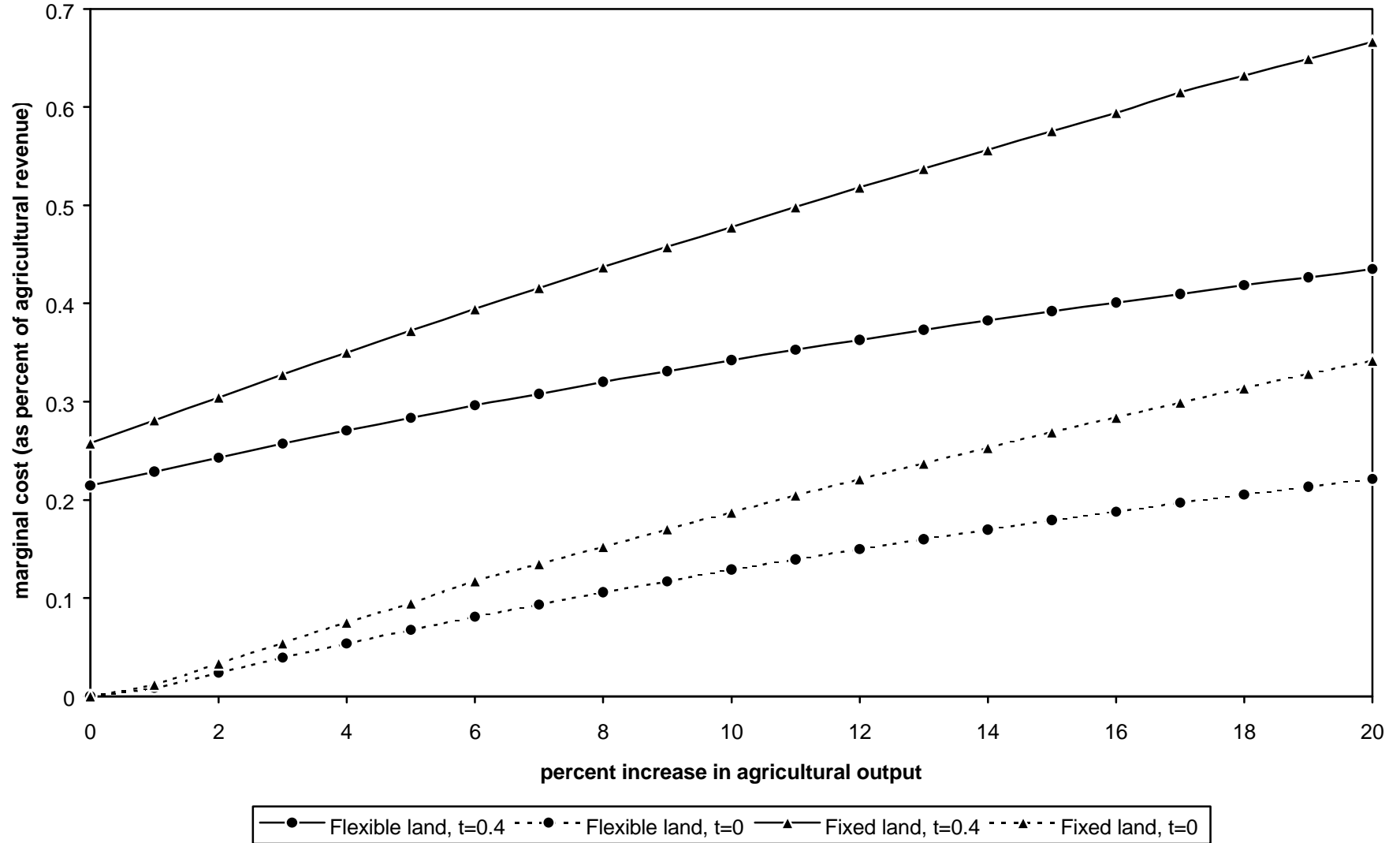
First, in the first-best case marginal costs are increasing. This reflects the increasing gap between marginal social cost (the height of the supply curve) and marginal social benefit (the height of the demand curve) as agricultural output is increased. The height of the (dashed) curves corresponds to the primary efficiency cost term (dW^P) in equation (2.11). Marginal costs are lower in the flexible land scenario, because of Le Chatelier's Principle--it is easier to increase agricultural output when land, as well as labor, can be transferred from the non-agricultural sector. Both curves have a zero intercept since the marginal benefit and marginal cost of producing *X* are equal when the subsidy is zero. They are also (slightly) concave, because the demand curve for agricultural output is convex.

Second, the effect of pre-existing taxes is to shift up the marginal cost curves so that they have a positive intercept (as predicted by the analytical model). This is because the efficiency loss from the revenue-financing effect dominates the efficiency gain from the tax-interaction effect. Thus, studies which do not take into account interactions with the tax system understate the *total* cost of production subsides by a potentially substantial amount. For example, the total cost of a 5 percent and 20 percent increase in agricultural output--the area under the marginal cost curve--is around 6.5 and 2.5 times as large in the second-best case relative to the first-best case (in both fixed and flexible land scenarios).

Third the absolute--as opposed to the proportionate--increase in marginal costs due to pre-existing taxes is a little greater when land is fixed than when land is flexible. This is because when land is fixed a larger subsidy is required to increase output by any given amount, which implies a larger net efficiency loss from the revenue-financing and tax-interaction effects.

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[34] For a discussion of these types of effects in the context of environmental regulation, see Bovenberg and Goulder (1997).

Figure 1. Marginal Cost of Produciton Subsidy

B. Production Quota

Figure 2 shows the corresponding marginal cost curves for a production quota that reduces agricultural output. This time the first-best marginal costs are convex since forgone incremental benefits from consuming *X* are increasing at an increasing rate. Marginal costs are higher in the first-best, fixed land case than the flexible land case--but only slightly so. This is because even when land is flexible it is not easily transferred from the agricultural to the non-agricultural sector, because the latter is relatively labor-intensive.

Again, the second-best marginal cost curves lie above the first-best curves and have positive intercepts, but for different reasons than in the subsidy case. Under the production quota, the tax-interaction effect raises rather than lowers the position of the marginal cost curve.[35] The total cost of reducing agricultural output by 5 percent and 20 percent respectively is approximately 4.5 and 2 times as large in the second-best case relative to the first-best case (when land is flexible or fixed). This means that neglecting the tax-interaction effect can lead to a substantial *underestimate* of the costs of a production quota.

C. Acreage Control

There are three noteworthy features in Figure 3. First, in the first-best case there is a substantial difference between the flexible and fixed land scenarios. In the flexible land case the marginal cost curve reflects the difference between the value marginal product of agricultural land *net* of the supply price of agricultural land. The value marginal product increases as land is reduced because it is increasingly difficult to substitute labor for land in agricultural production and because consumers are increasingly less willing to give up agricultural consumption. In addition, the return from transferring land to the non-agricultural sector is declining. For these reasons the marginal cost of reducing agricultural land is upward sloping. In the fixed land case, the reduction in agricultural land is left idle rather than transferred to the non-agricultural sector. Hence the marginal cost is the inverse of the value marginal product of agricultural land *gross* of the supply price of agricultural land. The value marginal product is more elastic in the fixed land scenario because households suffer a first order income loss from the reduction in land endowment and agriculture is a normal good. Thus, the marginal cost when land is fixed is initially well above that when land is flexible, however it has a flatter slope.[36]

Second, in the flexible land case pre-existing taxes actually slightly reduce the marginal cost of the acreage control. The policy raises the costs of agricultural production. This leads to a negative tax-interaction effect. However, this is more than offset by a favorable factor-shifting effect: the substitution between labor and land in the production of

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[35] The quota does produce an indirect efficiency gain because the quota tax revenues are used to reduce the income tax. However, this effect is dominated by the tax-interaction effect.

[36] Indeed the two curves eventually intersect. At this point, the height of the value marginal product curve in the fixed land case equals the gap between the value marginal product and the supply curve in the flexible land case.

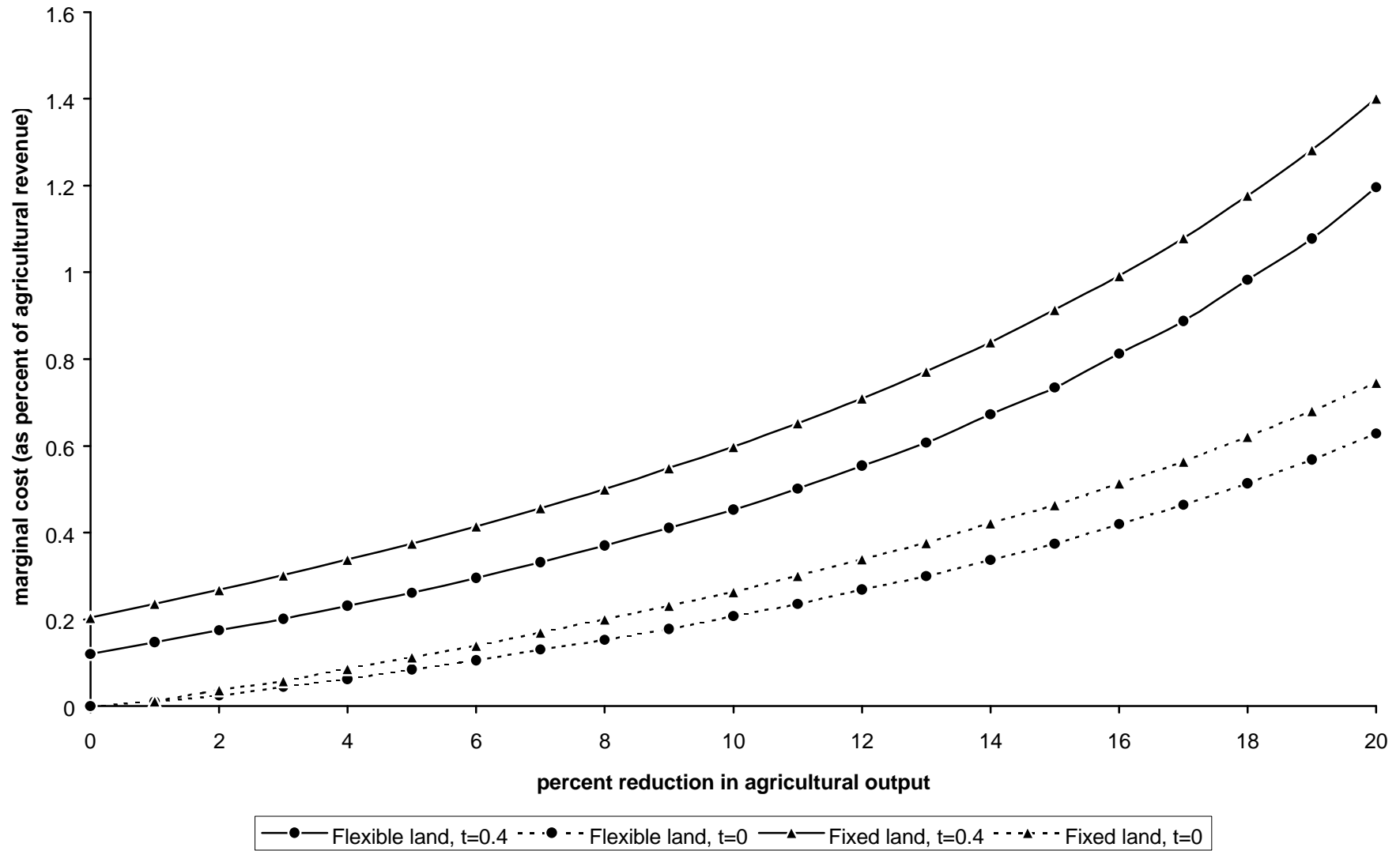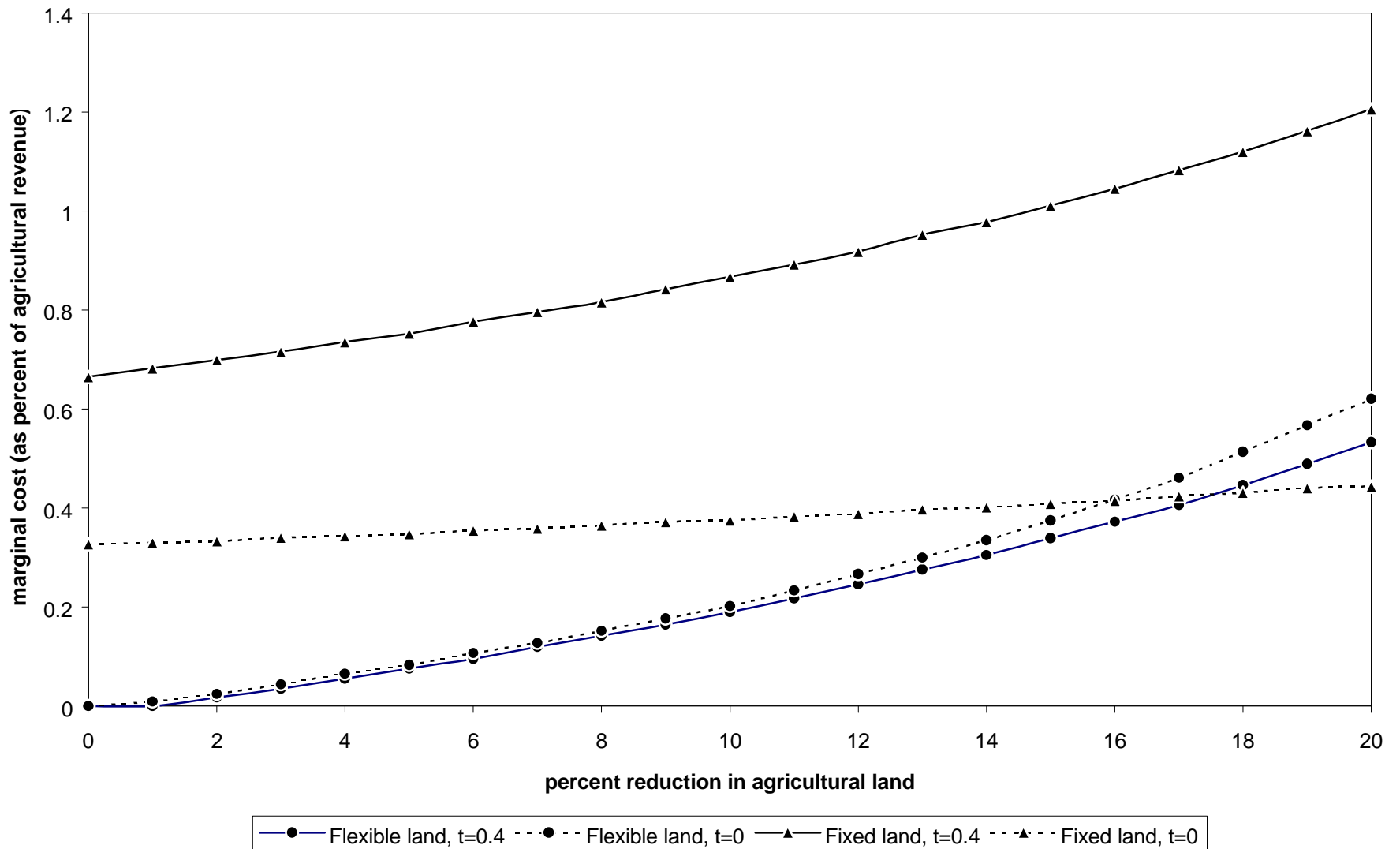# Figure 2. Marginal Cost of Produciton Quota

Figure 3. Marginal Cost of Acreage Control

agricultural output, and the shift from agricultural to non-agricultural production, both raise the demand for labor relative to land. This increases the price of labor and induces some substitution out of leisure.

Third, in contrast when land is fixed the acreage restriction is much more costly in the presence of pre-existing taxes. In this case the policy reduces the availability of land, rather than transferring it to a labor-intensive sector. This means that land rather than labor becomes the relatively scarce factor, resulting in a fall in the relative price of labor. Hence the factor-shifting effect reinforces rather than offsets the tax-interaction effect. In addition, the reduced base of the land tax implies a higher tax rate on labor to maintain budget balance.

D. SAR

The SAR policy is equivalent to the acreage control, except in one respect: it involves a payment from the government to agricultural producers equal to the subsidy rate multiplied by the reduction in agricultural land. This has no efficiency implications in the first-best case, since the payment is financed by lump sum transfers. Therefore, the marginal cost of reducing agricultural land under the SAR and acreage restriction policies are identical in the first-best case.

In the second-best case the subsidy payment is financed by distortionary taxation, and the revenue-financing and tax-interaction effects both imply efficiency losses. However the base of the subsidy is relatively "small" since it is the *reduction* in agricultural land (as opposed to the whole level of output in the case of the production subsidy). Nonetheless second best total costs of the SAR are still 2-3 times as high as first best costs, in both the flexible and fixed land scenarios.

E. Comparison of Policy Instruments

We now compare the costs of the policy instruments relative to those from an LST to pre-existing agricultural producers. We base the comparison on the amount of income the policy transfers to agricultural producers. This is calculated by revenue less labor and land costs; that is, the producer surplus arising from subsidy payments or rents generated by quantity controls. There are no efficiency costs from the LST in a first-best setting because it has no effect on output per producer, or the number of agricultural producers. However in a second-best setting, the LST leads to an efficiency loss from the revenue-financing effect. In our analysis, this efficiency cost equals 27 percent of the amount of income transferred. The curves in Figures 5a (flexible land case) and 5b (fixed land case) show the total (as opposed to marginal) efficiency costs of the above policy instruments for income transfers up to 10 percent of initial agricultural revenue.[37] These are expressed relative to the costs of the LST.

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[37] Annual government payments to farmers were 5-9 percent of gross farm income in the U.S. between 1990 and 1994 (see the *Statistical Abstract of the United States*).

Figure 4. Marginal Cost of SAR
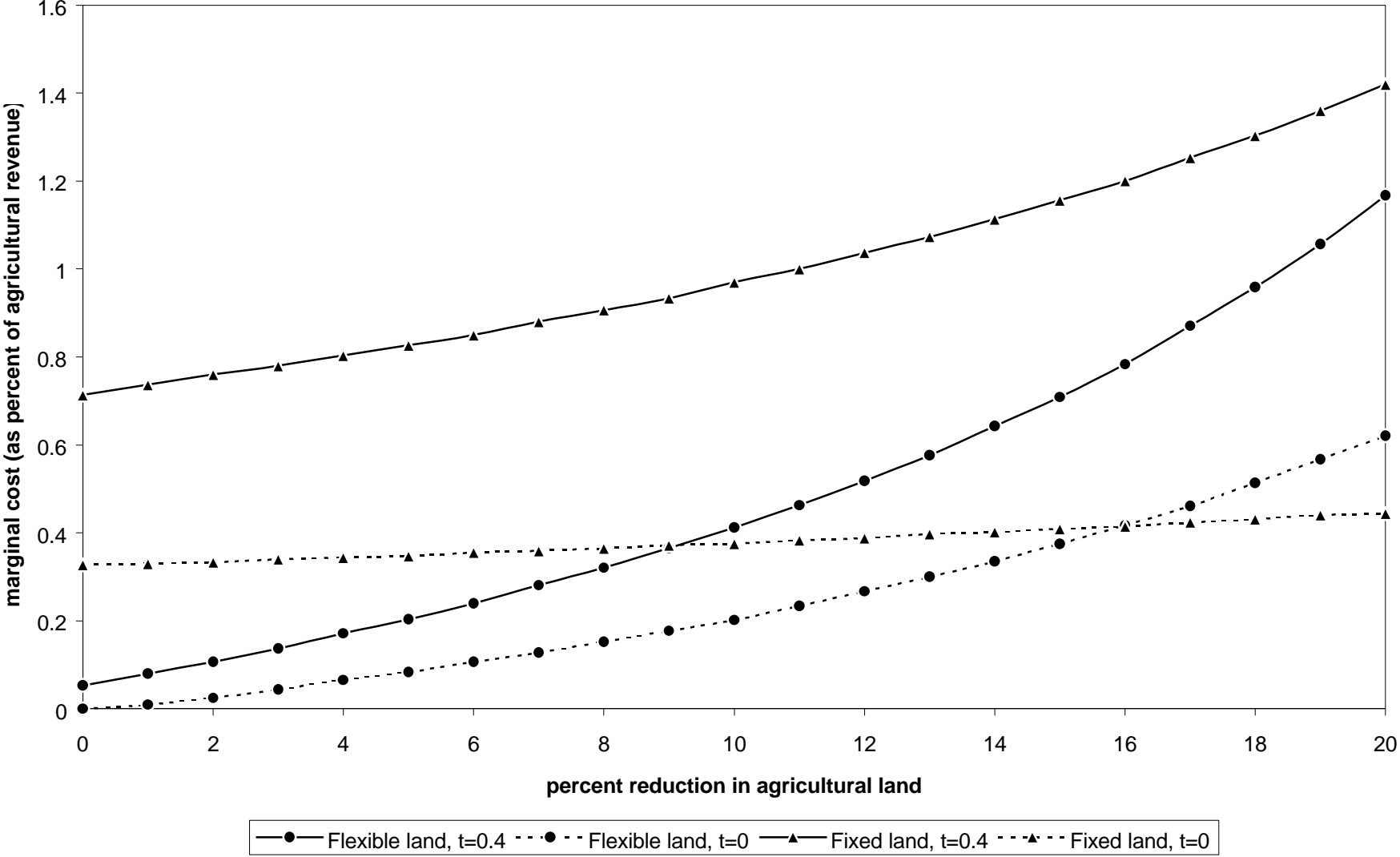
Therefore, when a curve lies below (above) the horizontal line at unity, the cost of the policy is less (greater) than that of the LST, for a given amount of income transferred to agricultural producers.

The production subsidy is very costly relative to the other policy instruments in the flexible land case. For example, it is 9-15 times as costly as the LST (this is not shown in Figure 5a). The reason is that the agricultural supply curve is relatively elastic and most of the subsidy payment "leaks" away in consumer surplus. Hence, a much higher subsidy payment is required to achieve a given net transfer to agricultural producers than with the LST, which involves no leakage. This means that the net efficiency loss from the revenue-financing effect, tax-interaction effect and primary cost under the production subsidy swamp the cost of the revenue-financing effect under the LST. When land is fixed the agricultural supply curve is much more inelastic and there is much less leakage to consumers. Consequently, the cost of the production subsidy falls to 1.3-1.6 times that of the LST (Figure 5b).

The production quota effects a transfer from agricultural consumers to producers. For the range of transfers considered the primary cost of the quota is relatively small. However, the tax-interaction effect raises the overall cost of the quota to 30-36 percent of the LST in the flexible land case and 48-56 percent in the fixed land case.

Due to the factor-shifting effect (see above) the acreage control would be the least costly way of raising income to agricultural producers in the flexible land case. *However*, in practice the reduced land under acreage controls is idled rather than transferred to other uses, hence the fixed land scenario is more realistic. In this case the policy is 3 times as costly as the LST. The cost of the SAR exceeds that of the acreage control because of the revenue-financing effect. Again the fixed land scenario is more realistic since land set aside under--for example the Conservation Reserve Program in the US--is idled. In this case the SAR is slightly more than 3 times as costly as the LST.

To sum up Figures 5a and b, the cost of the production subsidy exceeds that of the LST, which in turn exceeds that of the production quota, for the range of income transfers considered. Assuming the land taken out of agriculture is idled, the costs of the SAR and acreage control are much higher than that of the production subsidy.

F. Sensitivity Analysis

The above results are based on median estimates for parameter values. We now discuss how the costs of policies are affected by alternative assumptions about key parameters. The results are not particularly sensitive to different assumptions about the relative size of agriculture in the total value of output, the land to labor ratio in the agricultural sector and the elasticity of substitution in production.[38]

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[38] Changing these parameters may significantly affect absolute costs, but not as a proportion of agricultural revenue.

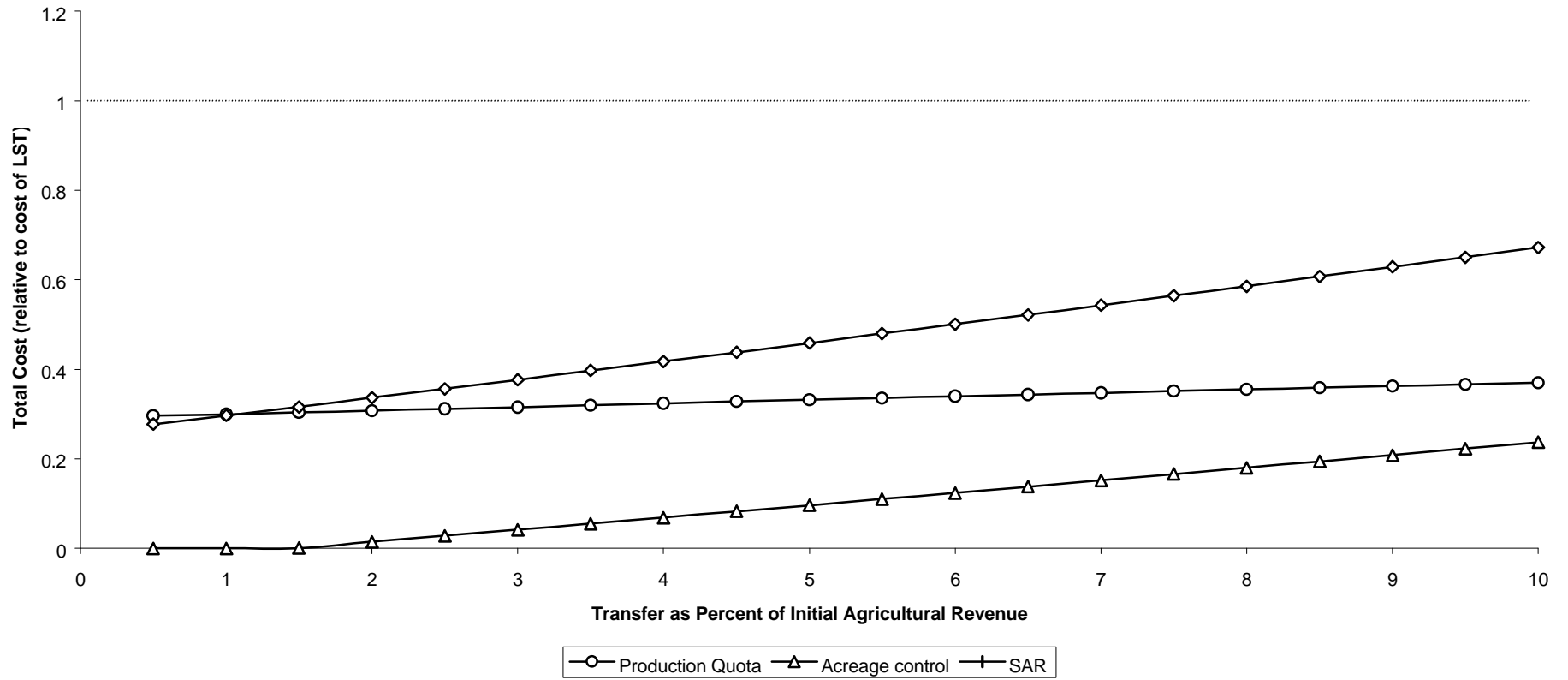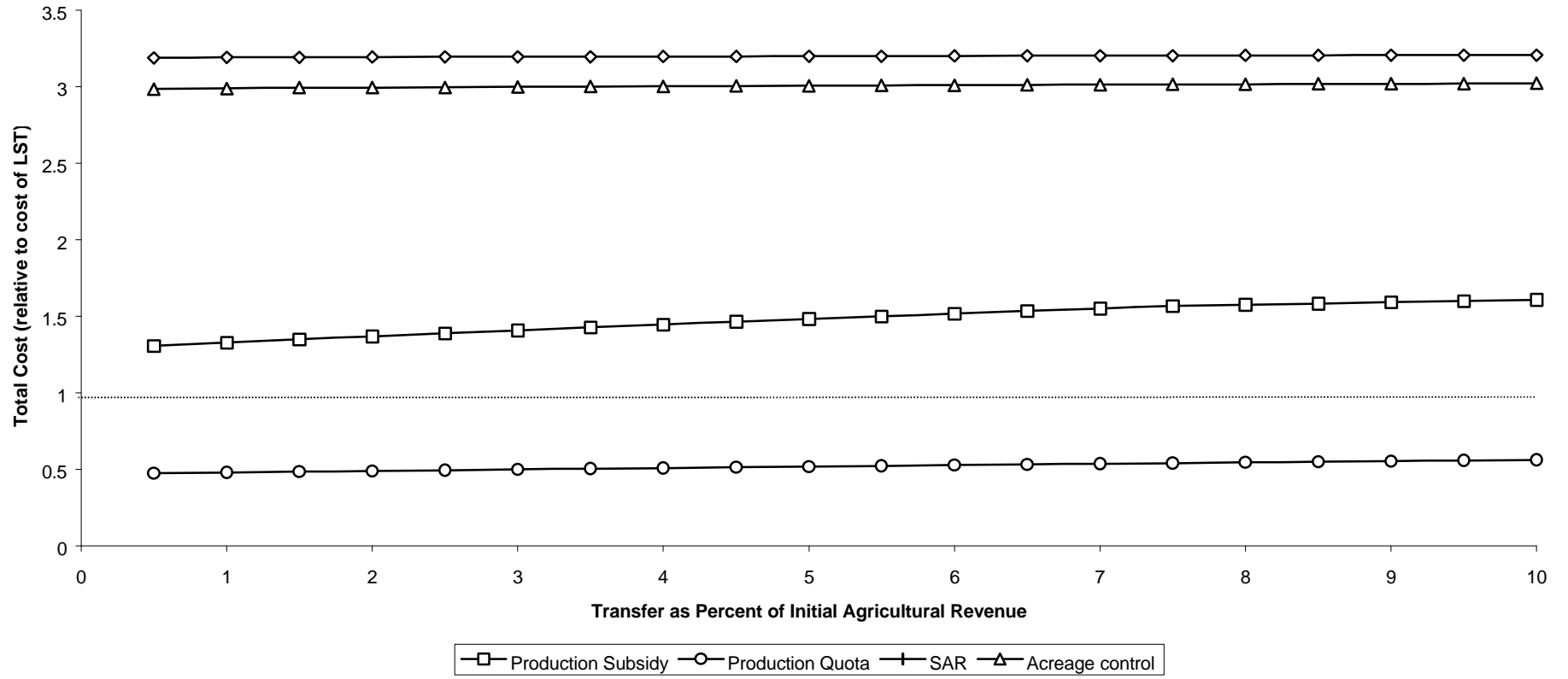**Figure 5a. Cost of Income Transfer: Flexible Land Case**

Figure 5b. Cost of Income Transfer: Fixed Land Case

The first row in Table 1 shows the intercept of the marginal cost curves in Figures 1-4 for the flexible and fixed land cases when the pre-existing income tax is 40 percent. The second row shows the effects on these intercepts from varying the consumption/leisure substitution elasticity to imply an uncompensated labor supply elasticity of between 0 and 0.3. This lowers or raises the intercepts for the production subsidy and production quota by roughly 50 percent in each direction. A higher labor supply elasticity implies a stronger tax-interaction effect and hence a higher (marginal) cost from the production quota. It also implies a greater net loss from the revenue-financing and tax-interaction effects under the production subsidy.[39]

Table 1. Sensitivity Analysis (Intercept of marginal cost curves)

		Production Subsidy	Production Quota	Acreage Control	SAR
1. Central case[a]	Flexible	0.21	0.12	0.00	0.05
	Fixed	0.26	0.20	0.67	0.75
2. Uncompensated labor supply elasticity = 0 − 0.3	Flexible	0.13–0.33	0.08–0.21	0.00–0.01	0.04–0.10
	Fixed	0.15–0.40	0.13–0.32	0.63–0.75	0.66–0.83
3. Agricultural demand elasticity = 0.1 − 1	Flexible	0.78–0.12	0.74–0.03	0.01–(-0.03)	0.77–0.02
	Fixed	0.88–0.17	0.88–0.11	0.69–0.67	0.76–0.72
4. Agricultural expenditure elasticity = 0.1 − 1	Flexible	1.07–0.05	0.10–0.33	-0.04–0.03	0.05–0.09
	Fixed	1.11–0.10	0.18–0.44	0.65–0.72	0.70–0.77

[a] Assumes an uncompensated labor supply elasticity of 0.15, agricultural demand elasticity of 0.4, and an agricultural expenditure elasticity of 0.4.

The third row varies the uncompensated demand elasticity for agricultural consumption between 0.1 and 1. A more inelastic demand curve implies a larger subsidy payment, and hence revenue-financing effect, to induce a given increase in output. It also implies a larger tax-interaction effect under the production quota, since the increase in product price is lower for a given reduction in agricultural output. Indeed the intercepts of the marginal costs under both production subsidy and production quota are 3-5 times as large, when the demand elasticity is reduced from 0.4 to 0.1.

The fourth row of Table 1 varies the agricultural expenditure elasticity between 0.1 and 1. The larger this elasticity, the greater the degree of substitution between agricultural consumption and leisure, and hence the larger the tax-interaction effect. This implies a lower marginal cost under the production subsidy and a higher marginal cost under the production quota.

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[39] The proportionate variation in costs is somewhat smaller under the acreage control and SAR, since the factor-shifting effect dampens the overall effect of pre-existing taxes.

5. CONCLUSION

This paper examines the costs of agricultural policies in a second-best setting with pre-existing tax distortions in factor markets. We analyze a production subsidy, production quota, acreage control, subsidy for acreage reduction and a lump sum transfer to agricultural producers. In general pre-existing taxes raise the costs of all these policy instruments and by a substantial amount--typically at least 100-200 percent. These additional costs reflect the revenue-financing and tax-interaction effects. The revenue-financing effect is the cost of financing subsidy policies by raising the rates of pre-existing distortionary taxes. The tax-interaction effect is the spillover effect in factor markets caused by changes in the relative costs of producing agricultural output. In the case of production quotas, acreage controls and subsidies for acreage reduction, the tax-interaction effect is an efficiency loss. In the case of a production subsidy, it is an efficiency gain and partially offsets the revenue-financing effect. On the basis of transferring income to agricultural producers, acreage controls and subsidies for acreage reduction are easily the most costly, followed by production subsidies, lump sum transfers and, least costly, production quotas. Thus, overall our results provide some support for the 1995 Farm Bill in the U.S., which replaced production subsidies and acreage controls for grains with lump sum transfers.

Some caveats to the analysis deserve mention. First, again we emphasize that the analysis focuses purely on the cost side of agricultural policies. A more complete evaluation of, for example, the conservation reserve program in the US would weigh economic costs against the environmental benefits. Second, the above analysis assumes a closed economy. In practice, agricultural commodities are traded between countries. A useful extension to the analysis would incorporate international trade and examine trade policies such as import tariffs and export subsidies. Third, the analysis examines agricultural policies in isolation. Another useful extension would disaggregate the agricultural sector and consider interactions between different agricultural policies, in addition to interactions with the tax system.

APPENDIX A

Deriving Equation (2.12)

From (2.10) and (2.11), $dW^1 = -ML(\partial L/\partial s)/(\partial L/\partial t)$. Substituting the Slutsky equations, and making use of the Slutsky symmetry property, we can obtain:

$$dW^1 = -\frac{ML\left\{\dfrac{\partial X^c}{\partial(1-t)} + \dfrac{\partial L}{\partial I}X\right\}}{\dfrac{\partial L^c}{\partial t} - \dfrac{\partial L}{\partial I}L} \tag{A1}$$

where "c" denotes a compensated coefficient and $I = (1-t)L$ is disposable household income. Differentiating (2.2) yields:

$$\frac{\partial L^c}{\partial t} = -\left\{\frac{\partial X^c}{\partial(1-t)} + \frac{\partial Y^c}{\partial(1-t)}\right\} \tag{A2}$$

Substituting (A2) in (A1), and using (2.2), we can obtain (2.12), where:

$$h_{XL}^c = \frac{\partial X^c}{\partial(1-t)}\frac{1-t}{X}; \qquad h_{YL}^c = \frac{\partial Y^c}{\partial(1-t)}\frac{1-t}{Y}; \qquad h_{LI} = \frac{\partial L}{\partial I}\frac{I}{L}$$

APPENDIX B: CALIBRATION OF THE NUMERICAL MODEL

(i) Agricultural Demand Parameters

Given the nested structure of the utility function, we can separate the allocation of consumer spending from the labor/leisure decision. Choosing X and Y to maximize utility from consumption (3.1b) subject to the budget constraint $p_X X + p_Y Y = E$, where E is expenditure on goods, we can obtain the following expenditure and indirect utility functions (see Varian, 1984, p. 130)

$$E - p_X \overline{X} = U\left\{a_c^{\frac{1}{1-r_c}} p_X^{\frac{r_c}{r_c-1}} + (1-a_c)^{\frac{1}{1-r_c}} p_Y^{\frac{r_c}{r_c-1}}\right\}^{\frac{r_c-1}{r_c}} \tag{B1}$$

$$V = (E - p_X \overline{X})\left\{a_c^{\frac{1}{1-r_c}} p_X^{\frac{r_c}{r_c-1}} + (1-a_c)^{\frac{1}{1-r_c}} p_Y^{\frac{r_c}{r_c-1}}\right\}^{\frac{1-r_c}{r_c}} \tag{B2}$$

Using (B2) and Roy's Identity, and setting prices equal to unity, the Marshallian demand for X is

$$X - \overline{X} = Z(E - \overline{X}) \tag{B3}$$

where

$$Z = \frac{1}{1 + (a_c/(1-a_c))^{-s_c}} \tag{B4}$$

From (B3) we can obtain the expenditure elasticity:

$$h_X^E = \frac{\partial X}{\partial E}\frac{E}{X} = \left(\frac{1 - \overline{q}_X/q_X}{1 - \overline{q}_X}\right) \tag{B5}$$

where $q_X = X/E$ is the share of agriculture in the total value of output and $\overline{q}_X = \overline{X}/E$. From (B5) we obtain values for $\overline{X}$ given q_X and different assumptions about h_X^E (and normalizing E to 100).

Using (B3), $Z = (q_X - \overline{q}_X)/(1-\overline{q}_X)$. Therefore, given values for q_X and $\overline{q}_X$, and using (B4), we obtain values for a_c.

Using (B1) we can obtain the compensated demand elasticity:

$$h_X^c = -\frac{\partial X^c}{\partial p_X}\frac{p_X}{X^c} = s_C\left(1 - \frac{\overline{q}_X}{q_X}\right)\left(\frac{1 - q_X}{1 - \overline{q}_X}\right) \tag{B6}$$

From the Slutsky equation $h_X^u = h_X^c - q_X h_X^E$. Given the uncompensated demand elasticity, h_X^u and the above values for q_X, $\overline{q}_X$ and h_X^E we obtain values for s_C.

(ii) Labor Supply Elasticities

The second household problem is to chose C and L to maximize (3.1a) subject to $p_c C = (1-t_I)(p_L L + p_K \overline{K}) + G$, where p_c is the price of composite consumption. Following a similar procedure we can obtain the following expressions:

$$e_L^u = \frac{r_L}{1 + r_K + (1-t_I)r_L}\{s_U(1+r_K) - (1-t_I)\} \tag{B7}$$

$$e_L^c = \frac{s_U r_L(1+r_K)}{1 + r_K + (1-t_I)r_L} \tag{B8}$$

$$r_L = \frac{\overline{L} - L}{L}, \; r_K = \frac{\overline{K}}{L} \; \text{and} \; \frac{\{a_U / (1 - a_U)\}^{-s}}{1 - \{a_U / (1 - a_U)\}^{-s}} = \frac{r_L}{1 + r_K + (1 - t_I) r_L} \tag{B9}$$

e_L^u and e_L^c are the uncompensated and compensated labor supply elasticities respectively. r_L is the ratio of leisure to labor time and r_K is the ratio of land to labor income. Given values for t_I, e_L^u, e_L^c and r_K we can infer s_U and a_U from these equations.

(iii) Agricultural Production Parameters

Using the cost function that is the dual of the production function in (3.3a), we can obtain the conditional demand function for agricultural labor:

$$L_X^c = \frac{X}{1 + (a_X / (1 - a_X))^{-s_x}} \tag{B10}$$

where factor prices are normalized to unity. Given the substitution elasticity s_X is unity a_X is easily inferred from the share of labor earnings in the value product of X. In the same way, a_Y in equation (3.3b) is easily obtained.

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