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Public Goods, Self-Selection and Optimal Income Taxation

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Abstract

Using the self-selection approach to tax analysis, this paper derives a modified Samuelson Rule for the provision of public goods when the government deploys an optimal non-linear income tax. This approach gives a straightforward interpretation of the central result in this area, generalises it, and provides a simple characterisation of optimal policy in a wide range of circumstances.

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I. Introduction

It is well-known that the famous Samuelson Rule for the provision of public goods may not be applicable when the tax revenues used to finance the public goods come from distorting taxes. The principle was recognized as long ago as Pigou (1947), long before the Samuelson Rule was devised. Pigou saw that in addition to the resource cost involved in transferring funds from the private to the public sector there was a deadweight loss involved. From this insight, he suggested that the criterion for providing public goods should be more stringent than the Samuelson Rule would later suggest. In particular, one might expect that the inclusion of the deadweight loss of taxes as part of the cost of providing a public good would lead to a reduction in its optimal provision relative to a situation in which lump-sum taxes were available.

The problem was investigated more systematically by Atkinson and Stern (1974), who considered the case in which a public good is financed by a set of optimal commodity taxes. All individuals were assumed to be identical, so efficiency alone dictated the objective. They found that no *prima facie* case could be made for the Pigou position that the use of distortionary taxes called for a reduction in the supply of the public good. Their analysis clearly showed that there were two influences at work when the financing of a public good was by distorting taxes. On the one hand, there was the Pigou effect that marginal increases in financing included not only the resource transfer from the private sector, but also a marginal deadweight loss. The combination of these has come to be known as the *marginal cost of public funds* and has been investigated in detail by Browning (1976) and Usher (1986). Their consensus seemed to be that the marginal cost of a dollar's worth of public funds was considerably more than one dollar. On the other hand, additional increments of public good supply will also affect government revenue through interactions that occur on the household demand side. Thus, for example, if public goods are complementary with highly taxed commodities, additional tax revenues will be forthcoming when public goods provision is expanded. Given the marginal cost of public funds, this additional revenue generated will reduce the opportunity cost of increments in the public good. In principle, the net effect of these two influences on the rule for providing public goods could go either way. That is, the Samuelson Rule may represent an under- or an over-provision relative to the commodity tax optimum.[1]

The exact determinants of the rule for optimal public goods provision under optimal linear taxation have been investigated by Wildasin (1984) and King (1986), among others. Particular attention has been paid to characterising the circumstances in which the two influences just noted exactly cancel out, so that the Samuelson Rule continues to be appropriate. This has come to be called the "decentralisation" issue: for the spending authority, in simply following the Samuelson Rule, need then pay no attention to the impact of its decisions on tax revenue. Preference restrictions that legitimise decentralisation when only linear taxes are deployed have been derived by Lau, Sheshinski and Stiglitz (1978) and Besley and Jewitt (1991). Public good provision with linear taxes is also the subject of a recent paper by Wilson (1991), who argues for a presumption — in striking contrast to the original Pigou intuition — that second best levels of provision typically exceed first best, at least for distributionally neutral public goods.

Public good provision with optimal non-linear taxes has received much less attention. It is this that is our primary concern here. Previous work has extended the Mirrlees (1971) model of optimal non-linear income taxation to include the use of the revenues for the provision of public goods. The central result in this area is that of Christiansen (1981) and Tuomala (1990), who show that if all households have the same preferences (over private goods, labour and a public good), then public goods provision can be decentralised if labour is weakly separable from goods (public and private) in the utility function. Quite why this is, however, has remained unclear. Moreover, if this separability condition fails to be satisfied, the conditions for optimal provision derived in these analyses become extremely difficult to interpret. In particular, there has emerged no clear delineation of the circumstances in which over- or under-provision are appropriate.

In this paper, we analyze the conditions for optimal provision of public goods in an economy with non-linear taxes using the self-selection approach to optimal taxation introduced to the literature seemingly simultaneously by Stern (1982), Stiglitz (1982) and Nichols and Zeckhauser (1982). We derive a modified Samuelson Rule that has a simple and appealing interpretation in terms of the self-selection constraint at the heart of the problem, one which is not well brought out in the continuum-household model of previous analyses. This provides both a generalisation of, and a clear explanation for, the Christiansen-Tuomala decentralisation result. Moreover, it gives a remarkably simple criterion for determining which way

[1] We define over- and under-provision more precisely below.

to deviate from the Samuelson Rule when that decentralisation result cannot be invoked: when all households have the same preferences, under- (over-) provision is optimal if and only if the public good is in a natural sense complementary with (substitutable for) leisure. The modified Samuelson Rule also leads to a number of sharp results for particular sorts of preferences, throwing further light, for example, on a central result in Wilson (1991).

II. The Model

Consider an economy consisting of persons of two levels of ability: w_1 and w_2, where $w_2 > w_1$. As is usual in the optimal income tax literature, production is linear in labour supplies and labour units are normalised so that wage rates equal ability levels. Persons of type i supply an amount of labour L_i, and consume X_i of a private good and G of a public good. The pre-tax income of a type-i person is:

$$Y_i = w_i L_i.$$

There are N_i households of type i. Households of type i have a strictly concave utility function $U^i(X_i, L_i, G)$. All households consume a common level of G, though the two types may value it differently. It is important to note at this point that we are allowing for households to have different preferences, unlike most of the traditional optimal income tax literature. The budget constraint of households is given by:

$$X_i = Y_i - T(Y_i)$$

where $T(Y_i)$ is a non-linear tax function chosen by the planner. The planner can observe total income of the household, but not its individual components, w_i and L_i. Thus, implicitly the planner can observe Y_i and X_i.

The planner chooses the tax function and the level of public goods so as to maximise some objective function. Following Stern (1982) and Stiglitz (1982), we can use the revelation principle to depict optimal government policy. In particular, we can write the planner's problem entirely in terms of the choice of X_i, Y_i and G, all of which the government can observe. To do so, we must first rewrite individual utility functions in terms of these variables as follows:

$$V^i(X_i, Y_i, G) = U^i(X_i, \frac{Y_i}{w_i}, G).$$

where the derivatives $V^i_X = U^i_X$, $V_Y = U^i_L / w_i$ and $V^i_G = U^i_G$.

We focus on the characterisation of second-best Pareto efficient tax-spending policies, and to this end consider the problem in which the planner maximises V^1

subject to a given level of V^2, $\bar{V}^2$. The planner faces two other constraints. One is a revenue constraint:

$$N_1(Y_1 - X_1) + N_2(Y_2 - X_2) = pG,$$

where p is the producer price of the public good. Given the linearity of the production side of the economy, p is fixed. The private good is the numeraire. The other is a self-selection constraint. Since persons cannot be identified by ability, the planner is constrained by the requirement that households must be at least as well off by accepting the consumption-income bundle meant for them as by accepting that meant for the other person. We consider the case in which redistribution goes from high- to low-ability persons. This implies that the binding self-selection constraint will be that which applies to high-ability persons mimicking low-ability ones:

$$V^2(X_2, Y_2, G) \geq V^2(X_1, Y_1, G).$$

The Lagrangian expression for the planner may therefore be written:

$$\begin{aligned}\Omega(X_i, Y_i, G, \delta, \lambda, \gamma) = V^1(X_1, Y_1, G) &+ \delta\left[V^2(X_2, Y_2, G) - \bar{V}^2\right] \\ &+\lambda\left[V^2(X_2, Y_2, G) - V^2(X_1, Y_1, G)\right] \\ &+\gamma\left[N_1(Y_1 - X_1) + N_2(Y_2 - X_2) - pG\right].\end{aligned} \tag{1}$$

Consider first the optimal income tax problem given some fixed amount of G to finance. The first order conditions on X_i and Y_i are:

$$V_X^1 - \lambda\hat{V}_X^2 - \gamma N_1 = 0 \tag{2}$$
$$V_Y^1 - \lambda\hat{V}_Y^2 + \gamma N_1 = 0 \tag{3}$$
$$(\delta + \lambda)V_X^2 - \gamma N_2 = 0 \tag{4}$$
$$(\delta + \lambda)V_Y^2 + \gamma N_2 = 0 \tag{5}$$

where $\hat{V}^2 = V^2(X_1, Y_1, G)$ represents the utility of the high-ability person when mimicking the low ability person. These conditions yield the conventional optimal income tax results of Stiglitz (1982). In particular, (4) and (5) yield $V_Y^2/V_X^2 = -1$, so the marginal tax rate on the high-ability person is zero. From (2) and (3) one can also deduce that the marginal tax rate on the low-ability person is between zero and 100%.

The optimal income tax solution is depicted on Figure 1.[2] It is worth explaining the intuition of it here for future reference. The diagram shows the utility levels

[2] The diagram makes the standard assumption that indifference curves in $X-Y$ space become flatter as the wage rate increases (the agent monotonicity condition of Seade (1982)). This is not needed for our analytical results.

achieved by the two persons, V^1 and V^2, in $X-Y$ space. Person i's consumption-income bundle is X_i, Y_i, and their tax liability is T_i. In this Pareto-optimising problem, the utility of person 2 is taken to be predetermined at $\bar{V}^2$. The maximum amount of revenue that can be obtained from a high-ability person is T_2, where the slope of the indifference curve V^2 is unity. This is just the result mentioned above that the high-ability person have a zero marginal tax rate. Given the amount of G to finance and the maximum tax revenue that can be obtained from each high-ability person, an amount of tax revenue T_1 must be obtained from each low-ability person. The dashed line shows the locus of points yielding T_1. The idea now is to choose the point along that line at which person 1 achieves the highest utility, consistent with the remaining constraint of the problem, the self-selection constraint. As one moves northeast along that locus toward the point (X_1, Y_1), person 1 becomes better off. Once that point is reached, the self-selection constraint becomes binding so no further movement is possible without violating the constraint. Thus, the points (X_1, Y_1) and (X_2, Y_2) shown in the figure constitute the solution to the problem. The important thing to note for our subsequent discussion is the important role that the self-selection constraint plays in limiting the extent to which the utility of the low-ability person can be raised.

III. The Public Goods Decision Rule

To determine the decision rule for public goods when optimal taxes are in place, differentiate (1) with respect to G to obtain:

$$\frac{d\Omega}{dG} = V_G^1 + (\delta + \lambda)V_G^2 - \lambda \hat{V}_G^2 - \gamma p.$$

Solving (4) for $(\delta + \lambda)$ and using (2) yields:

$$\frac{1}{\gamma}\frac{d\Omega}{dG} = \left[N_1 \frac{V_G^1}{V_X^1} + N_2 \frac{V_G^2}{V_X^2} - p\right] + \frac{\lambda \hat{V}_X^2}{\gamma}\left[\frac{V_G^1}{V_X^1} - \frac{\hat{V}_G^2}{\hat{V}_X^2}\right]. \tag{6}$$

This gives the change in social welfare measured in terms of public sector funds from an incremental increase in G financed by the optimal income tax.

It consists of two components. The first is the direct effect of increasing G on aggregate welfare: that is, the sum of benefits to all households less the resource cost of an increase in G. The second is the indirect effect of changes in G on the self-selection constraint. We return to its interpretation below.

An optimising planner will set (6) equal to zero, or

$$N_1 \frac{V_G^1}{V_X^1} + N_2 \frac{V_G^2}{V_X^2} = p + \frac{\lambda \hat{V}_X^2}{\gamma}\left[\frac{\hat{V}_G^2}{\hat{V}_X^2} - \frac{V_G^1}{V_X^1}\right]. \tag{7}$$

Using the properties of the utility function $V(\cdot)$, the left-hand side is the sum of marginal rates of substitution of G for X over all households ($\sum MRS^i_{GX}$). Similarly, the term $\hat{V}^2_G/\hat{V}^2_X$ is the marginal rate of substitution for the mimicker, denoted $\widehat{MRS}^2_{GX}$. We can thus rewrite (7) as follows:

$$\sum MRS^i_{GX} = p + \frac{\lambda \hat{V}^2_X}{\gamma}\left[\widehat{MRS}^2_{GX} - MRS^1_{GX}\right] \tag{8}$$

This shows that the deviation of the planning rule from the Samuelson Rule for public goods depends upon the term in square brackets. In particular, since[3] $\lambda/\gamma > 0$, we deduce the following proposition immediately from the modified Samuelson Rule (8):

> **Proposition 1.** In the presence of optimal income taxation, the rule for optimal public goods provision involves $\sum MRS^i_{GX} >,=,< p$ as the marginal evaluation of public goods to the mimicker is greater than, equal to, or less than that to the low ability person (i.e., $\widehat{MRS}^2_{GX} >,=,< MRS^1_{GX}$).

For brevity, we will refer to the situation of $\sum MRS^i_{GX} > p$ as "under-provision" of the public good relative to the Samuelson Rule, and vice versa (though we cannot say for certain that the level of G supplied will itself be lower).

This result can be given an intuitive interpretation by extending the logic of the optimal income tax result as explained above. To be concrete, consider the case in which the low-ability person values the public good more than the mimicker, so $MRS^1_{GX} > \widehat{MRS}^2_{GX}$. Here, equation (8) tells us that at the planner's optimum, $\sum MRS^i_{GX} < p$ so the public good should be "over-provided" relative to the Samuelson Rule. For this to be so, it should be possible to show that a Pareto improvement is possible starting at an optimal income tax equilibrium with the Samuelson Rule satisfied. To see that that will indeed be possible, consider the following exercise. Starting at $\sum MRS^i_{GX} = p$, imagine increasing G incrementally, and adjusting the income tax structure such that each person's tax liability rises by their MRS_{GX}. There will be no change in the welfare of either person 1 or person 2, and the government budget will not have changed. However, since the tax liability of the mimicking person will rise by MRS^1_{GX}, which is greater than the valuation $\widehat{MRS}^2_{GX}$, the mimicker will be worse off. The self-selection constraint is thus relaxed, and it is this that is captured by the last term of equation (8). With the welfare of both types unchanged at their intended bundles, but mimicking less

[3] From the definition of the Lagrangian expression in (1), it is apparent that tightening the self-selection constraint incrementally reduces the attainable level of V^1 by λ, and similarly tightening the budget constraint causes social welfare to fall by γ. Therefore, both λ and γ are positive.

attractive (i.e., the self-selection constraint relaxed), a change in the optimal income tax structure can then be undertaken which will make both persons better off. In terms of Figure 1, it is as if the economy is at the point S along the locus of constant T_1. The marginal tax rate on person 1 can be lowered with the same total tax revenue being collected. Person 1 is made better off, without inducing person 2 to mimic.

A special case of this is where the high ability person gets no utility from the public good at all, so their marginal evaluation is zero. Over-provision of the public good will then be a useful adjunct to income taxation as part of redistributive policy because of its effect on the self-selection constraint.[4] The argument is symmetric for the opposite case in which the mimicker has a higher marginal evaluation of G than the low-ability person. In this case, the exercise involves reducing G starting from the Samuelson Rule, and simultaneously reducing tax liabilities by the respective MRS's. Again, a Pareto improvement is possible in which both persons can be made better off. Equivalently, social welfare can be improved in the sense that more redistribution can take place.

IV. Some Special Cases

The above proposition is a very general one allowing the two types of households to have arbitrary and differing sets of preferences. It is also instructive to consider some special cases where consumer preferences are restricted. We start by characterising the circumstances in which decentralisation is optimal:

> **Corollary 1.** The Samuelson Rule for public good provision applies in the presence of optimal income taxation if the utility function for person i can be written in the form: $U^i(H[X_i, G], L_i)$; that is, if X_i and G are weakly separable from L_i in the utility function and the sub-utility functions in X_i and G are identical across households.

The proof follows immediately from (8) by noting that the only difference between the mimicking person and the low-ability person is the amount of labour supplied: both consume the same amount of X and G, but the mimicker supplies less L. From Goldman and Uzawa (1964), we know that weak separability is necessary and sufficient for the MRS^i_{GX} $(= V^i_G/V^i_X)$ to be independent of L, and thus for $\hat{V}^2_G/\hat{V}^2_X = V^1_G/V^1_X$.[5]

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[4] Nichols and Zeckhauser (1982) discussed a similar phenomenon in the context of the provision of private goods.

[5] It is tempting to say that, since weak separability is both necessary and sufficient for independence, Corollary 1 should read if *and only if*. Strictly speaking

Corollary 1 is a generalisation of the decentralisation result of Christiansen (1981) and Tuomala (1990), who assumed tastes to be identical across households. It shows that utility functions need not be identical; only the preference ordering of the separable component involving private and public goods. That is, persons may have different preferences between a composite of G and X on the one hand, and L on the other, but they must agree on what that composite is. Thus, for example, persons can have different relative preferences for leisure and the decentralisation result will still go through. The intuition for this result — far from clear in the continuum context of earlier treatments — is immediate from the discussion following Proposition 1 above. The preference restriction in Corollary 1 implies that a perturbation of the kind considered there would have no effect on the self-selection constraint, the change in the tax that the mimicker would then pay being exactly offset by the marginal benefit they derive from the public good.

Consider next the case usually presumed in the optimal tax literature: that in which all households have the same preferences. The following then applies:

> **Corollary 2.** Suppose the preferences of the two ability types are identical. Then, in the presence of optimal income taxation, the rule for optimal public goods provision involves $\sum MRS^{i}_{GX} >,=,< p$ as MRS_{GX} falls, stays unchanged, or rises with labour supply L.

In this central case there thus emerges a straightforward but, it seems, previously unnoticed condition determining the direction in which optimal policy deviates from the Samuelson Rule when decentralisation fails: under-provision is optimal — the marginal social cost of public funds exceeds unity at the optimum — if and only if the public good is complementary with leisure in the sense that marginal willingness to pay rises with leisure.

Again, the proof is apparent from (8) using the fact that labour supply is higher for the low-ability person than for the mimicker, while G and X are the same. The interpretation is again clear from the discussion of Proposition 1: if G is substitutable with leisure in the sense that its relative value falls with increases in leisure then marginal willingness to pay will be less for the high-ability mimicker, and the planner can make mimicking less attractive (weaken the self-selection constraint) by raising the level of G above that of the Samuelson Rule; and, vice versa.

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we cannot do so since it is possible that, even if the utility functions are not weakly separable, nonetheless at the optimal income tax solution $\hat{V}^2_G/\hat{V}^2_X = V^1_G/V^1_X$ so that the Samuelson Rule applies. However, if we want to be sure that the Samuelson Rule applies for all possible parameters of the problem, we would need to assume weak separability.

A final special case of interest is that in which utility is additively separable in the public good. Suppose then that (in some representation) the utility function, still assumed identical for all, can be written as:

$$U(X, L, G) = A(X, L) + B(G). \tag{9}$$

Since,

$$\frac{\partial MRS_{GX}}{\partial L} = \frac{1}{(U_X)^2}(U_X U_{GL} - U_G U_{XL}),$$

the feature of (9) that $U_{GL} = 0$ implies, recalling Corollary 2, that:

> **Corollary 3.** Suppose the preferences of the two ability types are identical and take the form $A(X, L) + B(G)$. Then, in the presence of optimal income taxation, the rule for optimal public goods provision involves $\sum MRS^i_{GX} >, =, < p$ as $A_{XL} >, =, < 0$.

An equivalent way of putting this is to say that in the additively separable case public goods should be over-provided relative to the Samuelson Rule if consumption and labour are Edgeworth substitutes (i.e., $U_{XL} < 0$), or, equivalently, consumption and leisure are Edgeworth complements. This result can usefully be compared to one of Wilson (1991). It is shown there that if preferences are of the form in Corollary 3 with the further restriction that $A(\cdot)$ be homogeneous of degree one in X and leisure, then the first-best level of public goods provision is actually below the second-best level associated with the use of linear taxes. Indeed, this special case is a central part of Wilson's argument for a general presumption that second-best levels of provision exceed first-best. In the present context, note that with $U_{XX} < 0$ linear homogeneity of $A(\cdot)$ implies[6] $A_{XL} < 0$. Corollary 3 then implies that when optimally non-linear taxes are deployed, the public good should in these circumstances be over-provided relative to the Samuelson Rule. Though there seems to be no result in the present context analogous to Wilson's on the level of public good supply, the analysis does help explain why this very particular form of preferences yields such a striking result.

V. Concluding Remarks

The above results were derived in the simplest of models chosen so as to be able to illustrate the central considerations in the clearest of ways. The basic intuition could, however, be extended to more complicated settings. An obvious extension would be to economies consisting of more than two types of consumers. This is quite straightforward.

[6] Bearing in mind that homogeneity is in leisure, not L.

Consider an economy consisting of n different types of households. Suppose that all households have the same preferences. In this case, there can be as many as $n-1$ self-selection constraints which preclude persons of a given ability from mimicking those of lesser ability. Indeed, it may well be that less than $n-1$ such constraints bind, since it is well-known that, in multi-person optimal income tax models, partial pooling equilibria can be optimal. That is, more than one type of person may choose the same $(X-Y)$ combination. (See Stiglitz (1982), Guesnerie and Seade (1982), and Brito *et al* (1990).) In this n-person economy, the condition for the optimal choice of G will be analogous to (8). It will state that G should be chosen such that the sum of the MRS_{GX}'s is equated to p plus a series of additional terms involving $(\widehat{MRS}^i_{GX} - MRS^j_{GX})$, one for each self-selection constraint, where mimicker i is of higher ability than person j who is being mimicked.

As before, for each self-selection constraint, the mimicker will differ from the person being mimicked only by the fact that the former supplies less labour (takes more leisure). Thus the analogs of Proposition 1 and Corollaries 1–3 apply. If X and G are separable in the utility function from L, and if the sub-utility functions in X and G represent the same preference ordering over (X, G) for all households (which will be the case if they have identical tastes), $\widehat{MRS}^i_{GX}$ for each mimicker will

be the same as MRS^j_{GX} for the person being mimicked. All terms involving the self-selection constraint will drop out, and the Samuelson Rule will result. Similarly, if MRS_{GX} rises with leisure (falls with labour), the mimicking terms will be positive and the optimum will involve under-provision of G, and vice versa.

Other extensions could be considered as well, though we do not pursue them here. One could add more than one private good to the model. As long as private goods are separable from leisure, the Atkinson-Stiglitz (1976) result that differential commodity taxes are not desired applies. In this case, the private goods can be taken as a composite commodity and the results of this paper all apply. If private goods are not separable from leisure, differential commodity taxation is desired and the problem becomes much more complicated, with or without public goods.

Finally, more than one public good could be added to the analysis without much difficulty. Each public good gives rise to a condition such as (8) which can be interpreted as before. For example, for any public good which is separable along with the private good from leisure, the Samuelson Rule applies. In the absence of such separability, over- or under-provision will be optimal depending in a now familiar way on the marginal evaluations of the public good concerned.

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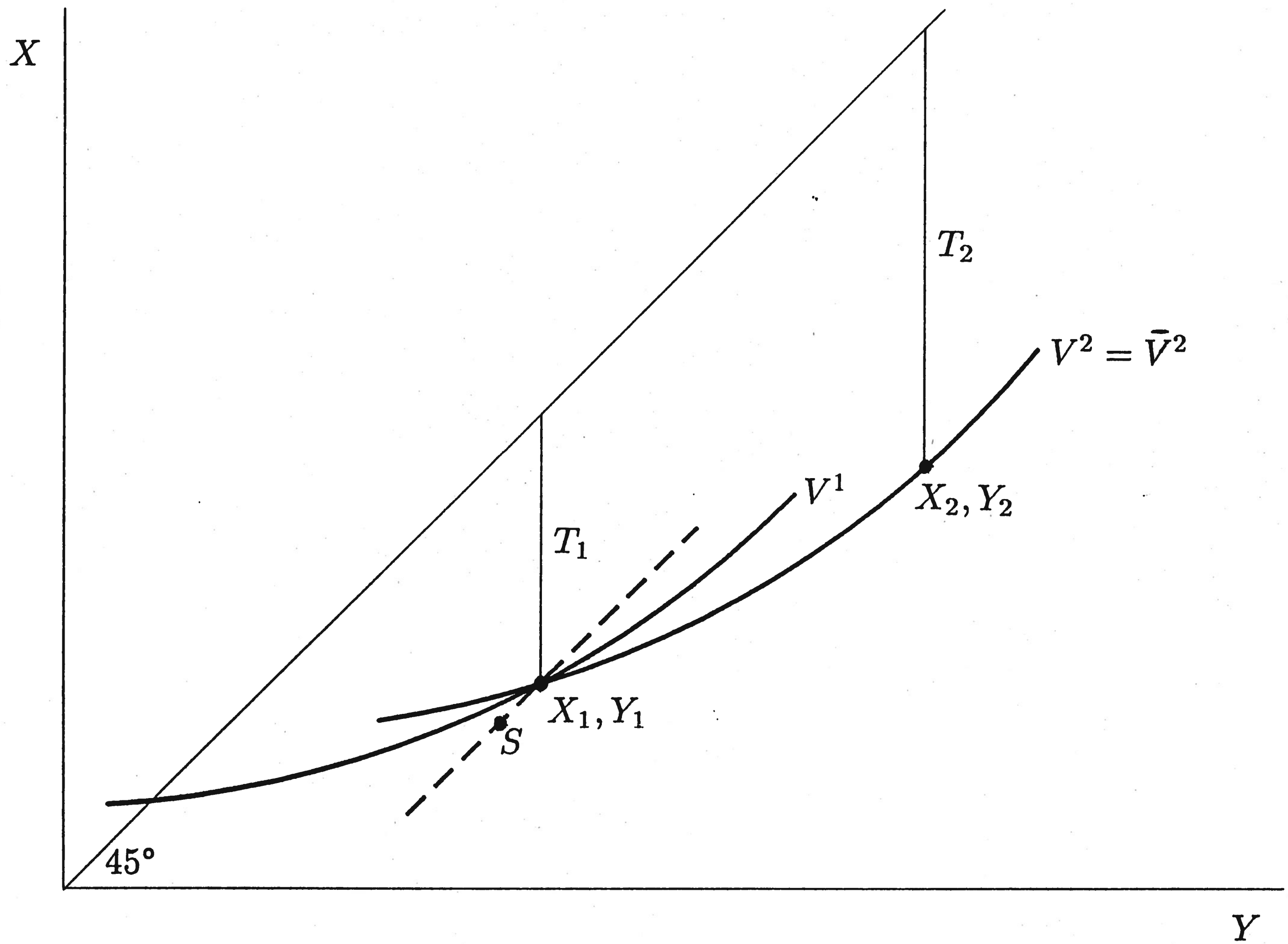

Figure 1