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Optimal Export Diversification Models : A theoretical Framework for Thai Export Crops

by

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I. Introduction

Over the period since 1950 export commodity diversification has taken place in Thailand. As far as export crops are concerned, rice, which has always dominated other crops in terms of export and production, has over the period reduced its share in total export earnings. Other export crops, e.g. corn, cassava and kenaf, have noticeably increased their shares in total earnings from abroad. However, it is found that the relationship between export diversification and instability in export earning in Thailand is not as simple as it is generally expected to be.[2] For instance, while export commodity diversification is found to help stabilize export earnings in the 1951 - 1962 period, it has a destabilizing effect on export earnings in the later period. In explaining this perverse effect of export diversification we note that Thailand has in recent years diversified its exports into some new and relatively unstable agricultural crops, such as sugar and kenaf.

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[1] This article is a modified version of chapter 5 in the author's Ph.D. dissertation (9).

[2] See Koomsup (9), chapter 3, pp. 43-78

It is, therefore, useful to examine the actual process of export diversification, particularly diversification in export crop production. For example, we want to know if the crop mix that we observe in the actual production of export crops can be explained by some optimizing behaviors of producers. Specifically, we want to find out to what extent the concept of risk aversion can be used to explain the way in which farmers diversify their export crops. In a policy-related issue, it is generally believed that the rice premium is one of the factors which encourage diversification in export production by making rice production less attractive. We hope to be able to ascertain the effects that the rice premium has on the agricultural export production pattern in Thailand.

In order to accomplish the tasks stated above, we will develop in this article a theoretical framework in which we can determine if a certain export crop mix is optimal. This will also enable us to examine how the rice premium has affected the pattern of crop production, particularly the production of rice in Thailand. The concept used here is that of the maximization of an utility function which incorporates a notion of risk aversion; and an assumption of food self-sufficiency requirement is also included in one of the models. In addition, we will take into account not only instability in earnings, but we will consider the expected value of earnings in the analysis as well. Some motivations, concepts, objectives, and assumptions of the framework will be discussed, then the theoretical models will be presented.

II. Motivations and concepts

In this section we will discuss the motivations of the models developed later in section IV. Most of the concepts discussed below will eventually be incorporated in the models.

(1) We will limit our analysis to only agricultural export. The first reason why we do so is that they are the most important category of exports in Thailand in terms of both the percentage in total export earnings and the effect on the economy as a whole. The second reason is that agricultural export are usually regarded as being notoriously unstable since income from them depends heavily on the vagaries of weather conditions and, for some, on the ups and downs of economic conditions in the industrial nations which import them. These are mainly reflected in changes in their yields and prices which are, in most cases, relatively more volatile than those of industrial goods. Since the production of these agricultural exports depends heavily on the amount of land available, the analysis essentially amounts to the problem of optimal land allocation among different export crops.

(2) While the use of "gross" earnings may be sufficient for the analysis of the impact of exports on various macroeconomic variables, such as income and government revenue, what is more relevant to the use of domestic resources (e.g. land, labor) should

be "net" export earnings. Net earnings are defined as the excess of gross earnings over total domestic resource costs and any costs of imports used in export production.[3] For instance, if we believe, as we assume in this study, that land is a scarce factor, these net earnings at a farm level can be represented by net returns on the land used in crop production. Alternatively, if we are interested in the farmers' managerial and entrepreneurial effort in organizing and hiring the factors of production in order to produce export crops, then these net earnings are the farmers' profit. The use of net earnings is more satisfactory since it takes into account the costs of producing exports, while the concept of gross earnings ignores them. For instance, a high-priced crop may involve high production costs, and may be considered worthwhile producing if its gross export earnings are used as a criterion. But compared with other cheaper crops, it may become less profitable in the sense that its net export earnings are relatively less. Hence, using gross earnings to select crops for export could possibly be misleading.

(3) It is more appropriate to include in our analysis the expected value of returns on each export group as well as instability in the returns. In may be reasonable to produce crops with fluctuating returns if their expected values of returns are high enough to compensate for the risks involved. We have mentioned,

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[3] This approach is similar to the concept of domestic resource costs, except that no comparison between the domestic resource cost ratio and the accounting or shadow-price exchange rate is considered here. For the concept of domestic resource costs, see Bruno (4).

for example, that the Thai agriculture has diversified towards some new crops which exhibit relatively more uncertainty in gross (and perhaps net) export earnings. This may be entirely rational if expected earnings from these crops are high enough to induce the farmers to grow them.. Therefore, both the mean (as a measure of expectation) and variance (as a measure of instability) of income may be important in the decision on the choice of crops grown. This indeed is the essence of the mean-variance analysis which will be used in this study.

(4) A concern over instability generally implies some degree of risk aversion. If no aversion is assumed, any fluctuations in income can be ignored. Recent studies on agricultural production, particularly in LDC's, have paid more attention to the role of risk and have found it to be rather significant. [4]

Thus, it is more realistic to assume the maximization of utility that depends on a kind of returns, such as profit,

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[4] A number of articles have been written on the importance of risk in agricultural production, both for developed and less developed countries. One of the pioneers in this field is Freund (7). The most recent works on risk in less developed agriculture are by Wiens (13), and Wolgin (14). Behrman in this study on the supply response of four annual crops in Thailand (2) also finds the farmers' response to risk to be significant.

rather than assuming, as the the basic theory of the firm, the maximization of profit itself, since it is possible to introduce the concept of risk aversion in the first type of maximization, but not in the second one.

A distinction should be made between social and private risk aversion. In the real world the degrees of both types of risk aversion with regard to agricultural export production, particularly in LDC's, may differ considerably for several reasons. Brainard and Cooper argue that private producers tend to underestimate the costs of risks because they consider only the risks incurred by themselves, and not those by others. For instance, variations in incomes of other groups in the economy represent social costs and yet are ignored by private producers. Fluctuations in government revenues and the economy's importing capacity caused by unstable export proceeds are not taken into account by the export producers in making their own production decisions.[5] Therefore, the degree of private risk aversion tends to be less than that of social risk aversion. As a result, left alone, the individual producers' decision to produce or invest will tend to exhibit a greater degree of riskiness than what is socially optimal.

But it may be argued, on the other hand, that there are some risk costs borne by the individual producers, and yet ignored by the society as a whole. This is found particularly in most underdeveloped agricultural economies. The farmers in these

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[5] Brainard and Cooper (3), pp. 274-75

economies must sometimes put the goal of food self-sufficiency as their first priority in making their decisions on the pattern of production. The result in Behrman (5) seems to support the hypothesis that Thai farmers first plant enough area in rice to insure subsistence for their families, and then allocate the remainder of their land among saleable crops.[6] The evidence supporting this hypothesis is found to be stronger in the relatively less commercialized areas. This seemingly traditional behavior may stem from the fact that the internal market for and distribution of agricultural products are not developed well enough to induce the farmers to produce cash crops in exchange for other goods, as well as for rice in the cases where not enough rice is grown for on-farm consumption. Therefore, if insufficient food crops are grown, a bad harvest and/or low prices for cash crops could bring disastrous results in the form of starvation, or heavy indebtedness, or a loss of control on land, or a combination of these. In the countries where any form of social security assistance does not exist, the costs of these risks are not met by the societies. Moreover, when income from food crops is more stable than that from cash crops, the producers' decision to grow more food than what is socially optimal may reflect the degree of private risk aversion to income instability which is higher than

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[6] Behrman (2), pp. 309-11

that of social risk aversion. Here, the production or investment by the individual producers will entail a less degree of riskiness than what is considered optimal from the social point of view. Therefore, it is not clear a priori how the degrees of private and social risk aversion in the production of agricultural exports in LDC's would differ.

(5) Given the difference in the degrees of private and social risk aversion, it is likely that what is socially optimal diversification in export crops does not necessarily coincide with what is considered privately optimal. There are also other reasons why the two kinds of optimal diversification may differ :

(i) The individual producers may not be able to diversify their production to the desired extent. This may be caused by imperfect capital market which is common in most LDC's, or by inadequate facilities, e.g. storage facilities and water.

(ii) Due to the lack of information on the costs and returns of different crops, the opportunity for diversification perceived by the individual producers could be different from what is seen by the government. This argument assumes that the government possesses more accurate information than the producers, though, in fact, this is not necessarily the case. Indeed, it may be true that the individual farmers can obtain more and more accurate information on prices and costs from middlemen and merchants than government officials do.

(iii) The society and the producers may be maximizing their utility functions which depend on entirely different variables. It may be reasonable to assume an utility maximization which ensures self-sufficiency in food, both at the national and individual farm levels. Then net income from the sale of the surplus of food crops and the output of cash crops, will determine the level of utility, both social and private. While the government, acting on behalf of the society, is concerned with net foreign exchange earnings, the producers' utility depends on net farm income which differs from net foreign exchange earnings if part of the marketed surplus are sold domestically.

(iv) Taxation can affect private risk-taking in some ways. For instance, when there is no tax offset for losses, taxation on profits creates a bias against risky production. On the other hand, if the government tends to subsidize some risky crops when income from them declines as a result of a bad harvest or low world prices, there is an incentive for the producers to take more risks than when no subsidy exists. [7]

The difference between the degree of social risk aversion and that of private risk aversion and the other reasons above may be viewed as domestic distortions, similar to the cases of rigid

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[7] For this point, see Corden (5), pp. 320-21.

wages, immobility of labor, and other forms of distortions. Then the first-best solution should be the use of policy measures that are directed towards the sources of the distortions. For instance, if lack of information is the cause of distortion, the best policy is for the government to disseminate to the farmers more information on prices and prospects of the crops to be grown. If the producers cannot diversify their crops simply because they cannot borrow money at a reasonable interest rate, then the best way is to provide more credit to them. However, some of the causes of distortions cannot be eliminated by first-best policies because of lack of expertise and administrative capacity on the part of the government. In most LDC's, the only option left for the government is some fiscal measures, which in most cases are the second- or third-best solutions.

Though some kind of government intervention may be needed to bring socially optimal diversification and privately optimal diversification together,[8] it is not at all clear that the intervention should be pro-or anti-risk. Lack

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[8] It should be noted here that Corden concludes that the degree of risk-taking by the producers is socially optimal. He argues that the costs associated with the means of risk reduction (e.g. issuing shares in the stock market, and insurance) are practically too high that it will be socially optimal to let private risk aversion determine production. Later he introduces some qualifications which seem to nullify his earlier conclusion. See Corden (5), pp. 319-22.

of information by the producers, for instance, could cause them to either overestimate or underestimate the risks associated with some crop patterns, thus could call for either pro- or anti-risk intervention by the government.

(6) There are several policy instruments which could be used to influence the private decisions on diversification in export production. The examples are various kinds of taxation, subsidies, price supports, production quotas, and other quantitative controls. But perhaps the most widely used instrument in LDC's seems to be export taxes. What makes export taxes a popular policy instrument is the fact that they involve relatively low collection costs due to the existence of a few and rather homogeneous export products and sometimes a few main producers.[9] It must be emphasized here that in general the primary goal of export taxes is not so much to influence production patterns as to create government revenue. This is also true in Thailand where the tax on rice exports-- the rice premium-- was at first designed to siphon some of the profits from rice exporters just after the end of the second World War. Later through the years the rice premium, together with other instruments, such as export quotas and rice reserve requirement, has been used by the government, more towards the goal of keeping down domestic rice prices and, consequently, the general cost of living, and of ensuring sufficient domestic supply of rice. All these create a wedge between

[9] Corden (5), p. 66.

the world prices and the domestic prices of rice, and also affect both the means and variances of the prices received by rice farmers. Thus, intentionally or not, the rice premium and other policies on rice exports are likely to have some effects on agricultural diversification in Thailand. It is debatable as to what and how much influence these policies have had on crop diversification in the last two decades. Most agree that since the rice premium depresses the farm prices of rice, the Thai farmers would find other crops such as corn, cassava, and kenaf more attractive to grow. [10] However, when the "risk" effect of the policies is included, it is possible that the rice premium may have stabilized the farm prices of and income from rice, and thus may have encouraged more rice growing. [11] Moreover, the policies may have made income from rice less highly correlated with income from other crops, and thus have made rice growing a good choice for hedging against uncertainty in prices and yields. The question of how significant the risk effect of the rice premium on crop diversification has been will hopefully be partially answered in this article, at least at the theoretical level.

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[10] Behrman (2), p. 312, and Silcock (11), p. 214.

[11] The risk effect is also mentioned by Behrman, but he ignores the interaction of risk responses for different crops, i.e. no covariances among prices of and income from various crops are considered.

III. Objectives

The objectives of the export diversification models developed in this article are as follows :

(1) As we discuss in the last section, it is more appropriate to include both the expected values of returns and some measures of riskiness in the analysis of instability and diversification of exports. Thus, given the means and variances of net income from most export crops in Thailand, we would like to derive various alternatives of "efficient" land allocation among these crops. They are efficient in the sense that, given all possible values of expected total returns, their variances representing the degree of riskiness are at their minima. These efficient combinations of crop production are represented by an "efficiency frontier", the concept of which will be discussed later in detail.

(2) We want to assess how much the mean-variance analysis which incorporates the notion of risk aversion can explain changes in the pattern of agricultural export production in Thailand in various regions. To be specific, we want to see how closely the actual crop mixes in different regions correspond with those represented by the optimal points on the efficiency frontiers.

(3) Since, as mentioned in the previous section, the government rice policies which include the use of the rice premium are believed to have some influence on the prices received by rice farmers, we want to find out how the rice policies have affected agricultural export diversification. Specifically, we want to know how the policies, particularly the use of the rice premium, have changed both the means and variances of the farm prices of rice, and how these changes have intereacted with those in the prices of other crops, and consequently affected the pattern of export crop production. We should also be able to determine the effect of the rice policies on the farmers' welfare.

(4) Finally, our analysis should add to the process of agricultural planning in Thailand another dimension which has so far been neglected. That is, it provides a framework in which uncertainty in prices and yields of export crops can be taken into account in the policies concerning export diversification. Thus, given some future forecast on the means and variances of income from various export crops, we will be able to provide some policy guidelines with respect to the optimal diversification in agricultural export production.

IV. Optimal export diversification models

IV.1. Model I

Assumptions :

(1) The utility to be maximized by the producers of

export crops and by the government, acting on behalf of the society, depends on net returns from export crops. The quadratic form of utility function will allow expected utility to depend on the level of expected net returns as well as the variance of net returns.

(2) Agricultural production is assumed to have constant input-output coefficients. The only exception is for land input where crop yields are allowed to fluctuate. Yet this is not reflected in the input-output matrix, but in gross revenue.[12]

(3) The amount of arable land is given and every acre of it can produce all crops in question. This assumption should be changed somewhat in empirical work because it is clear that each acre is actually suitable for only some and not all crops.

(4) The country's share of world market in each crop is not great enough for it to influence world prices simply by imposing export taxes or subsidies or any other trade barriers. Hence the domestic price of an export crop equals its world price minus (plus) the specific export tax rate (subsidy rate) on it. All marketing marketing margins are ignored, and domestic prices

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[12] Allowing all input-output coefficients to fluctuate would make the computation very difficult, if not impossible, to solve. In any case, the assumption of constant input-output coefficients (except yields) seems technologically realistic in most underdeveloped agriculture.

are the same as those received by the producers. Taxes and other trade policy instruments, therefore, affect both the means and variances of domestic prices. Empirically, the marketing margins should be included to reflect reality as much as possible.

(5) The existence of risks is mainly reflected in fluctuations in crop yields and farm prices. Fluctuations in both can be represented by a variance-covariance matrix of total net returns. The prices of inputs are assumed to be constant.[13] To distinguish between private and social costs, input prices should be represented by the shadow prices of inputs for social utility maximization, and by the market prices for private utility maximization.

Symbols : The symbols used in model I are defined as follows :

Let X_i = the level of activity of crop i. A unit level of activity could be defined as being equivalent to a unit of land or a certain amount of revenue. i = 1, 2,..........,n.

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[13] Though the assumption of constant input prices may appear too restrictive, fluctuations in them are generally considerably less than those in crop prices, and thus for all practical purposes they are assumed constant.

f_i^g , f_i^p	=	the net returns at a unit level of activity of crop i for the society and the producers respectively.
B^g , B^p	=	the total net returns for the society and the producers respectively.
P_i	=	the world price of crop i.
P_i^d	=	the domestic price of crop i.
W_j	=	the shadow price of input j; $j = 1, 2, \ldots, m$.
V_j	=	the market price of input j; $j = 1, 2, \ldots, m$.
Y_i	=	the output of crop i per unit level of activity.
a_{ij}	=	the amount of input j needed to produce output i at a unit level of activity.
T_j	=	the given amount of input j available; let T_1 be total land input available.
b	=	the degree of social risk aversion, $b < o$
b^*	=	the degree of private risk aversion, $b^* < o$

Let the following vectors and matrices be defined as :

$$X = \begin{bmatrix} X_1 \\ X_2 \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ X_n \end{bmatrix} \qquad f^g = \begin{bmatrix} f_1^g \\ f_2^g \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ f_n^g \end{bmatrix} \qquad f^p = \begin{bmatrix} f_1^p \\ f_2^p \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ f_n^p \end{bmatrix}$$

$$p = \begin{bmatrix} p1 \\ p_2 \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ p_n \end{bmatrix} \quad p^d = \begin{bmatrix} p_1^d \\ p_2^d \\ \cdot \\ \cdot \\ \cdot \\ p_n^d \end{bmatrix} \quad w = \begin{bmatrix} w_1 \\ w_2 \\ \cdot \\ \cdot \\ \cdot \\ w_m \end{bmatrix} \quad v = \begin{bmatrix} v_1 \\ v_2 \\ \cdot \\ \cdot \\ \cdot \\ v_m \end{bmatrix} \quad T = \begin{bmatrix} T_1 \\ T_2 \\ \cdot \\ \cdot \\ \cdot \\ T_m \end{bmatrix}$$

$$Y = \begin{bmatrix} Y_1 & 0 \cdot \cdot \cdot \cdot 0 \\ 0 & Y_2 \cdot \cdot \cdot \cdot \cdot \\ 0 & 0 \; Y_3 \cdot \cdot \cdot \cdot \cdot \cdot \cdot \\ \cdot & \cdot \\ \cdot & 0 \\ \cdot & \\ 0 & \cdot \quad \cdot \cdot 0 \; Y_n \end{bmatrix} \qquad A = \begin{bmatrix} a_{11} & a_{12} & \cdots\cdots a_{1m} \\ a_{21} & a_{22} & \cdots\cdots a_{2m} \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ a_{n1} & a_{n2} & \cdots\cdots a_{nm} \end{bmatrix}$$

$$\mu^g = \begin{bmatrix} \mu_1^g \\ \mu_2^g \\ \vdots \\ {}_n^g \end{bmatrix} \qquad \mu^p = \begin{bmatrix} \mu_1^p \\ \mu_2^p \\ \vdots \\ \mu_n^p \end{bmatrix}$$

where μ_i^g, μ_i^p = the expected values of μ net returns at a unit level of activity of crop i for the society and the producers respectively.

Σ^g, Σ^p = the variance = covariance matrices of f^g and f^p respectively.

Model proper :

The net returns are defined as the gross revenue minus all input costs. Hence

$$f^g = Yp - Aw \quad \text{and} \quad f^p = Yp^d - Av.$$

The total net returns are the sum of the net returns from all crops grown. Hence

$$B^g = (f^g)' X \quad \text{and} \quad B^p = (f^p)' X.$$

And the expected values and variances of the total net returns for the society and the producers are:

$$E(B^g) = (\mu^g)' X \quad \text{and} \quad E(B^p) = (\mu^p)' X$$

$$V(B^g) = X' \Sigma^g X \quad \text{and} \quad V(B^p) = X' \Sigma^p X$$

To allow for risk-averse behaviors, let the utility functions for both the society and the producers be respectively:[14]

$$U^g = B^g + \frac{b}{2} \left[B^g - E(B^g) \right]^2$$

and $$U^p = B^p + \frac{b}{2} \left[B^p - E(B^p) \right]^2$$

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[14] This form of quadratic utility function is used in Brainard and Cooper (3) in their appendix. It can be justified as an approximately correct way of looking at the returns on some particular investment since the mean value of returns measures the amount we would normally expect to obtain in the long run, while the variance indicates how risky the investment is. One theoretical objection to the kind of quadratic utility function is that it implies increasing absolute risk aversion. This property leads to a rather unlikely conclusion that the demand for risky assets decreases with income or wealth. For this criticism, see Arrow (1), pp. 35-36

An alternative to the Brainard-Cooper approach is a combination of an exponential utility-of-income function and the assumption of normally distributed returns. This approach, which is used in Freund (7) and Weins (13), leads eventually to an objective function which is equivalent to the expected utility function above. Though the exponential form exhibits constant, instead of increasing absolute risk aversion encountered in the first approach, the assumption of a normal distribution of returns may be unrealistic. A normal distribution tails off to infinity on both plus and minus sides, while infinite gains and losses are nonexistent in the real world. But for all practical purposes, the criticisms on both approaches are not seriously damaging and can generally be overlooked.

Taking expectation:

$$E(U^g) = (\mu'^g)X + \frac{bX'}{2} \Sigma_g X \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

and

$$E(U^p) = (\mu'^p)X + \frac{b^*X'}{2} \Sigma_p X \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Thus, as equations (1) and (2) show, expected utility depends not only on mean income, but also on the variance of income which indicates the degree of riskiness. Here the government and the individual producers will maximize the expected utility functions in equations (1) and (2) respectively, subject to the same input constraints:

$$AX \leq T$$

and

$$X \geq 0$$

In the simple case where all marketing margins are ignored and the difference between the shadow and market prices of inputs areassumed away, without any kind of government intervention, there is no difference between the world prices and the domestic prices and $\mu^g = \mu^p$ and $\Sigma^g = \Sigma^p$. Both the government and the producers will maximize the same function, except only for the difference in the degrees of risk aversion, b and b^*.[15] As discussed

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[15] If the social and private costs of production are different due to the difference between the shadow and market prices of inputs, then we have another reason to believe that the socially optimal diversification and the privately optimal one are not likely to be same. The means and variance-covariance matrices in equations (1) and (2) will have different values in this case.

in the previous section, it is not a priori certain that b is greater or less than b^*. If the costs of risks are underestimated by the producers, as argued by Brainard and Cooper, i.e. $b^* > b$, then they will be likely to produce more of the high-risk crops and less of the low-risk crops than what are consiered socially optimal. In this case some anti-risk government intervention may be needed. For instance, taxes can be imposed on the export or on the production of the high-risk crops to discourage their production and encourage more production of the low-risk crops. Subsidization on the export or on the production of the low-risk crops will have similar effects.[16] On the other hand, if the producers overestimate the costs of risks, i.e. $b^* < b$, the crop mix grown will be biased towards more of the low-riskccrops than in the socially optimal mix. This may call for some pro-risk government measures, e.g. export taxes on the low-risk crops.[17]

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[16] The fiscal measures which bring private diversification towards being socially optimal can in fact be any kind of taxes (or subsidies) which affects the producers' decision to grow. In this study we will concentrate on export taxes (or subsidies) because, as noted before, they are most widely used by LDC's where income taxes and excise taxes in the agricultural sector are much more difficult to administer. However, it should be recognized that export taxes (or subsidies) may creat additional trade distortions. See H.G. Johnson (8).

[17] It should be noted that the effects of export taxes on production are not unambiguous when the taxes change both the means and variances of prices of the taxed crops, and consequently those of the total revenue, such as the case of the rice premium in Thailand. Some discussion on this will be made later in section V.

Both situations are depicted in figures 1 and 2, where efficiency frontiers and indifference curves are drawn. An efficiency frontier represents the combinations of production of export crops which minimize the standard deviations of net returns for all possible values of their mean. In a two-crop case, the efficiency frontier is represented by a curve whose shape depends on the degree of correlation between the returns from the two crops. If the returns are perfectly and positively correlated, the frontier is a straight line connecting the two points each of which represents complete specialization in one crop. If they are perfectly negatively correlated, the frontier is represented by two straight-line segments connecting the two points with a common point on the axis representing the expected value of total returns. For an intermediate degree of correlation, the frontier looks like curves S_1S_1' , S_2S_2' , D_1D_1' and D_2D_2'= in figures 1 and 2. In a case where more than two crops are involved, the frontier is an "envelope" curve representing the boundary of the region which contains all possible production combinations. Its shape is also similar to those of the efficiency frontiers in figures 1 and 2. For a risk-averse person, the relevant portion of the efficiency frontier is where its slope is positive, since a negative slope would mean that higher risk is accociated with lower expected returns-- a choice more attractive to a risk lover. Thus we will consider only the positive slope portion of the efficiency frontier. This portion generally shows that higher expected returns are possible only through increasing risk at an increasing rate.[18]

A family of indifference curves is derived from the quadratic expected utility function used in this study. The slope of an indifference curve is $dE/d\sigma = -b\sigma$, where E is the expected returns, σ is the standard deviation of returns, and b is the degree of risk aversion. The positive slope indicates risk aversion in the sense that more risk (i.e. higher standard deviation of income) will be taken only if expected returns are higher. The increase of the slope as σ is greater shows the increasing rate of change in expected returns necessary for compensating for increasing risk.

An efficiency frontier can be derived by maximizing the same functions as those in equations (1) and (2), where $b/2 = -1$, for all possible values of mean net returns and with the same input constraints. It follows then that finding the highest

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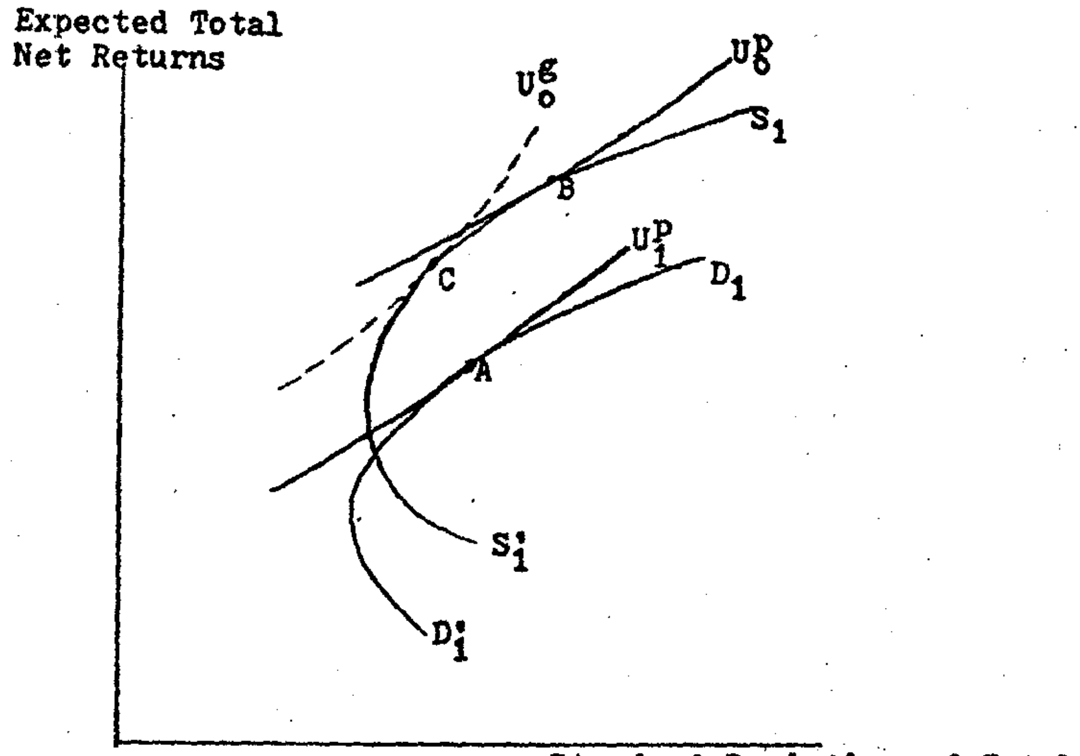
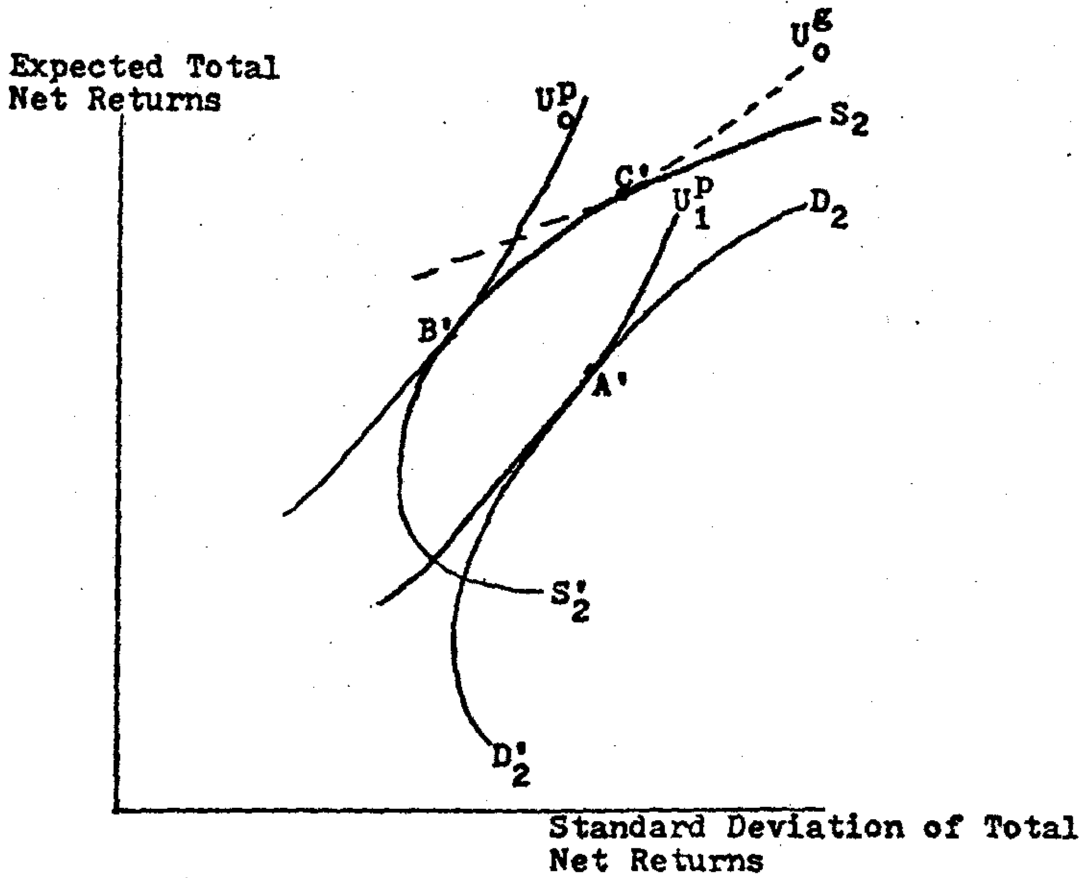
[18] The concept of efficiency frontier is developed by Tobin (12), pp. 65-86. For the discussion of the shape and meaning of the efficiency frontier in the context of export production, see Brainard and Cooper (3), pp. 266-268.



<u>**Figure 1 : Underestimation of Social Risk Costs by Producers, Model I.**</u>



<u>**Figure 2 : Overestimation of Social Risk Costs by Producers, Model I.**</u>

indifference curve which touches the efficiency frontier is equivalent to the maximization of the expected utility functions in equations (1) and (2) with the input constraints.

In figures 1 and 2, the vertical axis represents the expected value of total net returns, while the horizontal axis represents the standard deviation of total net returns. S_1S_1' and S_2S_2' are the efficiency frontiers when there is no government intervention, and D_1D_1' and D_2D_2' are the efficiency frontiers when domestic prices differ from world prices due to government intervention, such as export taxes or subsidies. In the case where the social costs of risks are underestimated by the individual producers (i.e. $b^* > b$), and without government intervention, they may decide to produce at point B in figure 1 where indifference curve U_o^p touches efficiency frontier S_1S_1' and where their expected utility is maximized. Whereas a higher degree of social risk aversion (i.e. the slope of social indifference curve U_o^g is higher than that of private indifference curve U_o^p) may indicate a socially optimal product mix at point C which is less risky than pont B. If the government policy is to gear the production towards the socially optimal diversification, it may use its tools, such as export taxes or subsidies, to create a new efficiency frontier, such as curve D_1D_1' , on which the producers will produce the same mix as the represented by point C and at the same time maximize their expected utility within the constraints of government intervention. For instance, the imposition of taxes on the export of risky crops may shift the efficiency frontier from S_1S_1' to D_1D_1' and cause the new production to be at point A which represents the same product mix as point C. The new maximum expected utility of the producers is likely to be less than the old one, while the expected social utility is at its maximum. The case where the social costs of risk are overestimated by the producers (i.e. $b^* < b$) is depicted in figure 2. Here, without taxes the socially optimal product mix at point C' is riskier than the privately optimal one at point B'. The government may impose export taxes on the low-risk crops, thus encouraging more production of the high-risk crops at point A' on D_2D_2'. Points A' and C' will represent the same crop mix, thus ensuring the simultaneous maximization of both social and private expected utility.

IV.2. Model II

Assumptions:

In this model, a distinction has to be made between food crop and cash crops. The former are those that are produced mainly for consumption by the farmers themselves. The output of food crops above and beyond the amount required for this consumption is marketed. A good example of food crops is rice in Thailand. On the other hand, cash crops are those that are produced mainly for sale. None or very little of the cash crops will be consumed by the farmers themselves or by the non-farm population in the economy. Most of the output of cash crops, such as corn, kenaf, and cassava in Thailand is sold abroad. Therefore, it is important to note that while marketed surplus and total domestic supply are not the same for food crops, there is practically no difference between the two in the case of cash crops.

All assumptions in model I are applicable in model II, except for the assumption on utility functions. As we discuss above in section II, it is found that in a food surplus country such as Thailand, most farmers would allocate land and other factors of production in such a way that self-sufficiency in staple crops (i.e. rice in the Thai case) is ensured before they decide on the production of cash crops. On the national level, the government's goal is in most cases to be self-sufficient in food crops before any exports are allowed. It may be politically suicidal for the government in a country like Thailand to let exports of staple food crops, such as rice, cause very large increases in their domestic prices and/or shortages of domestic supplies. In fact, most governments in Asia, for political as well as economic reasons, usually set their goals of making their countries self-sufficient in food, particularly staple food crops such as rice and wheat. However, the degree of success in this regard varies from country to country, depending mainly on the relationship between the available resources and the size of the populations. Therefore, it is realistic to incorporate the idea of food self-sufficiency in model II. Specifically, it is assumed that the government, acting on behalf of the society as a whole, will ensure domestic self-sufficiency in food crops before they can be exported. The individual producers, on the other hand, will try to produce enough food for themselves before production of other crops is decided upon.

Furthermore, as discussed in section II, it is reasonable to assume that, after ensuring domestic sufficiency in food, the government will maximize the utility which depends on net foreign exchange earnings, while the producers' utility depends on their net farm income, after they grow enough food for on-farm consumption. Net foreign exchange earnings will differ from net farm income if there is non-farm domestic consumption of some crops.

<u>Symbols</u> : In addition to the symbols used in model I, some new symbols are introduced here:

R = the total net foreign exchange earnings.

S = the total net farm income.

$\bar{C}_i$ = the fixed amount of food crop i required for on-farm consumption; $i = 1, 2, .., g$; $g < n$

$\bar{D}_i$ = the fixed amount of food crop i required for non-farm domestic consumption; $i = 1, 2, \ldots, g$; $g < n$.

X_i^F = the level of activity for food crop i designated for on-farm consumption; $i = 1, 2, \ldots, g$; $g < n$.

X_i^S = the level of activity for food crop i as a marketed farm surplus; $i = 1, 2, \ldots, g$; $g < n$

X_i^C = the level of activity for food crop i designated for total (i.e. on-farm and non-farm) domestic consumption; $i = 1, 2, \ldots, g$; $g < n$.

X_i^E = the level of activity for food crop i to be exported; $i = 1, 2, \ldots, g$; $g < n$.

$X_{g+1}, X_{g+2}, \ldots X_n$ are defined as in model I.

For a food crop, therefore, the total level of activity can be divided in two ways. First, it is consisted of the level of activity for export and that for total domestic consumption, i.e.

$$X_i = X_i^E + X_i^C \qquad i = 1, 2, \ldots, g$$

Secondly, it can be divided into the level of activity for marketed farm surplus and that for on-farm consumption, i.e.

$$X_i = X_i^S + X_i^F \qquad i = 1, 2, \ldots\ldots\ldots\ldots, g$$

Therefore, $X_i = X_i^E + X_i^C = X_i^S + X_i^F$

$$i = 1, 2, \ldots\ldots\ldots\ldots\ldots, g$$

And, if part of the output is consumed by the non-farm sector, then X_i^C is greater than X_i^F, and X_i^F must be less than X_i^S. Therefore, because net foreign exchange earnings from food exports depend on X_i^E and net farm income depends on X_i^S, the two are not the same. There is no distinction between X^E and X^S in the case of cash crops, since by definition their $X^F = X^C = 0$. In fact, for the cash crops, we have

$$X_i = X_i^E = X_i^S \qquad i = g+1, \ldots\ldots\ldots\ldots, n$$

Let

$$X^1 = \begin{bmatrix} X_1^E \\ X_2^E \\ \cdot \\ \cdot \\ \cdot \\ X_g^E \\ X_{g+1} \\ \cdot \\ \cdot \\ \cdot \\ X_n \end{bmatrix} \qquad X^2 = \begin{bmatrix} X_1^S \\ X_2^S \\ \cdot \\ \cdot \\ \cdot \\ X_g^S \\ X_{g+1} \\ \cdot \\ \cdot \\ \cdot \\ X_n \end{bmatrix}$$

Model proper:

The total net export earnings and the total net farm income are respectively the sums of the net earnings and the net farm income from all crops:

$$R = (f^g)' \; X^1$$

and

$$S = (f^p)' \; X^2$$

where f^g and f^p are defined in model I.

The expected values and variances of total net export earnings and total net farm income are respectively:

$$E(R) = (\mu^g)' \; X^1 \qquad E(S) = (\mu^p)' \; X^2$$

$$V(R) = (X^1)' \textstyle\sum^g X^1 \qquad V(S) = (X^2)' \textstyle\sum^p X^2$$

Again, incorporating the concept of risk aversion in the utility function for both the society and the individual producers, we have the following utility functions:

$$U^g = R + \frac{b}{2}\left[R - E(R)\right]^2 \quad \text{and}$$

$$U^p = S + \frac{b^*}{2}\left[S - E(S)\right]^2$$

Taking expectation on both functions, we have:

$$E(U^g) = (\mu^g)' \; X^1 + \frac{b}{2}(X^1)' \textstyle\sum^g X^1 \;.........(3)$$

$$E(U^p) = (\mu^p)' \; X^2 + \frac{b}{2}(X^2)' \textstyle\sum^p X^2 \;.........(4)$$

In this model the government and the producers will maximize their expected utility functions in equations (3) and (4) respectively.

Because of the way we define variables X^1 and X^2 in the utility functions in this model, the input constraints for the social and private maximization of expected utility are not the same. If we define the unit of activity level as a unit of land area, then the amounts of land allocated to the food crops intened for on-farm consumption and for total domestic consumption are respectively:

$$X_i^F = a_{i1}\bar{C}_i \qquad \text{and}$$

$$X_i^C = a_{i1}(\bar{C}_i + \bar{D}_i)$$

Where a_{i1} is the amount of land needed to produce a unit of food crop i, and i = 1, 2,........,g

For the social maximization of expected utility, the constraints are:

$$A' \; X^1 \leq T^*$$

$$\text{where} \quad T^* = \begin{bmatrix} T_1 - \sum_{i=1}^{g} a_{i1} \, (\bar{C}_i + \bar{D}_i) \\ T_2 - \sum_{i=1}^{g} a_{i1} \, a_{i2} \, (\bar{C}_i + \bar{D}_i) \\ \vdots \\ T_m - \sum_{i=1}^{g} a_{i1} \, a_{im} \, (\bar{C}_i + \bar{D}_i) \end{bmatrix}$$

That is, the constraints in the case are different from those in model I in that the inputs left for expected utility maximization are those in excess of the inputs allocated for production of food crops which ensures national self-suffieiency in food.

For the individual producers, the constraints are:

$$A' X^2 \leq T^{**}$$

where

$$T^{**} = \begin{bmatrix} T_1 - \sum_{i=1}^{g} a_{i1} \bar{C}_i \\ T_2 - \sum_{i=1}^{g} a_{i1} a_{i2} \bar{C}_i \\ \vdots \\ T_m - \sum_{i=1}^{g} a_{i1} a_{im} \bar{C}_i \end{bmatrix}$$

The input constraints for the producers are those above and beyond what have been allocated for production of the food crops to be consumed on the farm.

Like model I, even though there is not government intervention of any kind, both the society and the producers do not maximize the same expected utility function. But unlike model I, in the simple case where there is no difference between the shadow and market prices of inputs and all marketing margins are ignored, the source of difference is not only in the degrees of social and private risk aversion, but also in the means and variances of net export earnings and net farm income, even though domestic prices are the same as world prices. This, again, is because of the difference between X^1 and X^2.

Therefore, even though we know exactly how b and b^* differ, it is not certain that the producers' optimal crop mix will represent production with more or less risk than what is socially optimal. It all depends on the interaction between the differing degrees of risk aversion and the difference in the means and variances of R and S. If the producers end up produce more (less) of the high-risk crops than what is socially optimal, as defined by the maximum of expected social utility in equation (3), the government may use some anti-risk (pro-risk) policies, such as export taxes on the high-risk (low-risk) crops.

The two situations are graphically shown in figures 3a , 3b,, 4a , and 4b. Curve II' in figures 3a and 4a is the efficiency frontier representing all crop mixes which minimize the standard deviations of net export earnings for all possible values of their means. While curves WW' and LL' in figures 3b and 4b are the efficiency frontiers derived from net farm income without and with government intervention respectively. U^g and

U^p are the social and private indifference curves repectively. Fugures 3a and 3b depict the situation where the producers, without government intervention, produce a crop mix represented by point A in figure 3b which is equivalent to point B in figure 3a.[19] Since point C represents the socially optimal crop diversification, the production in this case exhibits higher risk than socially desirable. The government may step in by imposing some taxes on the high-risk crops, thus moving curve WW' to curve LL' and causing the new production at point D to coincide with that at point C. By taxation, the social expected utility is at its maximum, while the new maximum private expected utility (U_1^p) is likely to be lower than the previous one (U_o^p). It is, however, possible that U_1^p is higher than U_o^p. The opposite case is shown in figures 4a and 4b where the producers choose a crop mix at point A and equivalently at point B which involves less risk than what is socially optimal at point C. Taxes on the export of low-risk crops will create a new efficiency frontier (LL') and a new production point D which is equivalent to point C in the sense that they represent the same crop mix. Here, taxes are

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[19] For the sake of simplicity, point B is shown to be on efficiency frontier II. However, it is conceivable, and perhaps likely, that it is off the frontier.

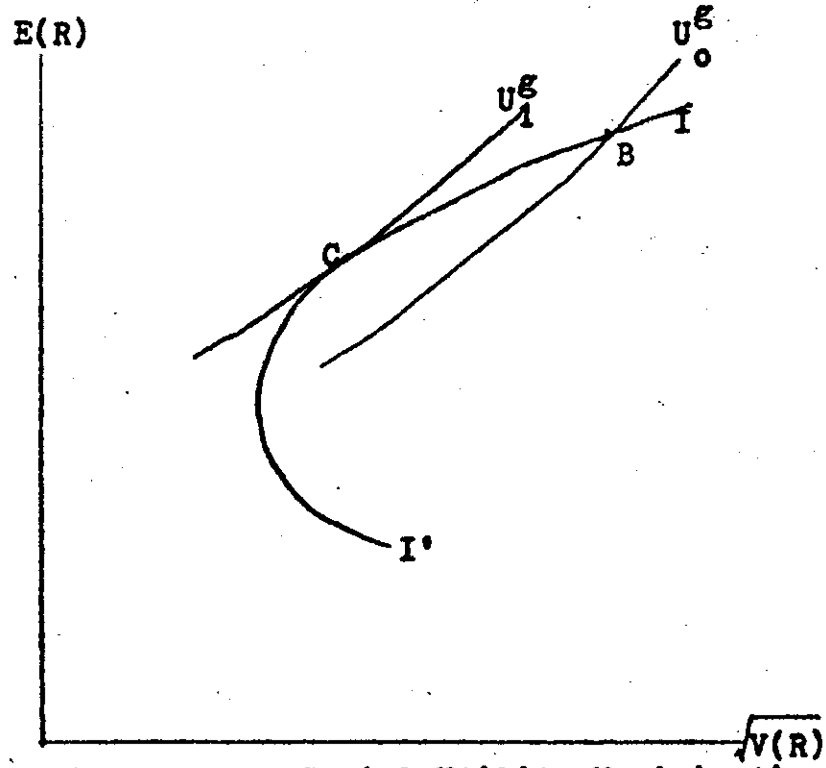

Figure 3a : Social Utility Maximization in the Case where Social Risk Costs are Underestimated by Producers, Model II

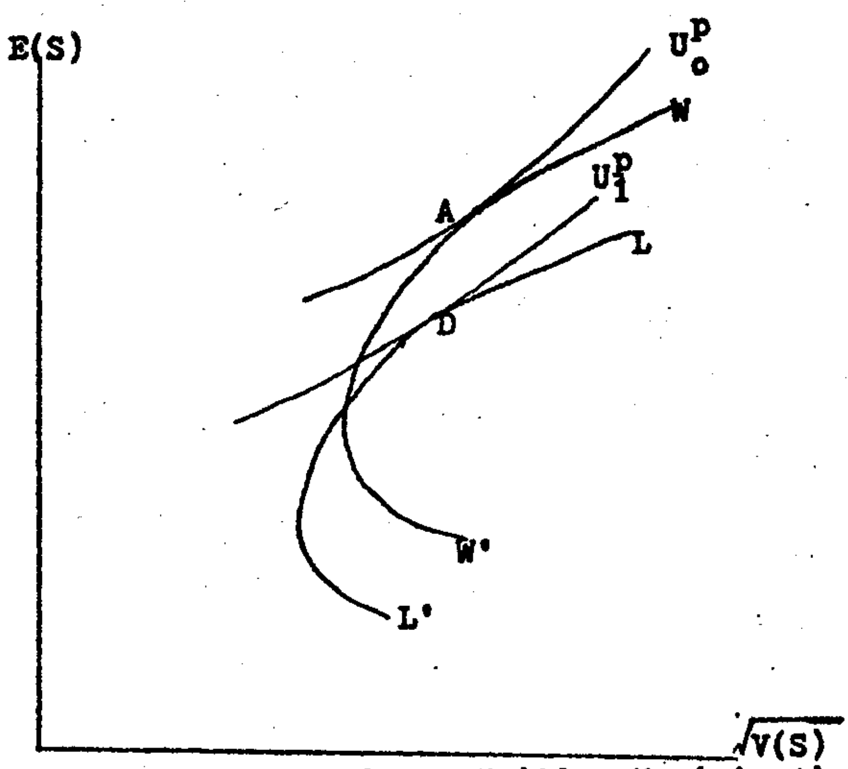

Figure 3b : . Private Utility Maximization in the Case where Social Risk Costs are Underestimated by Producers, Model II.

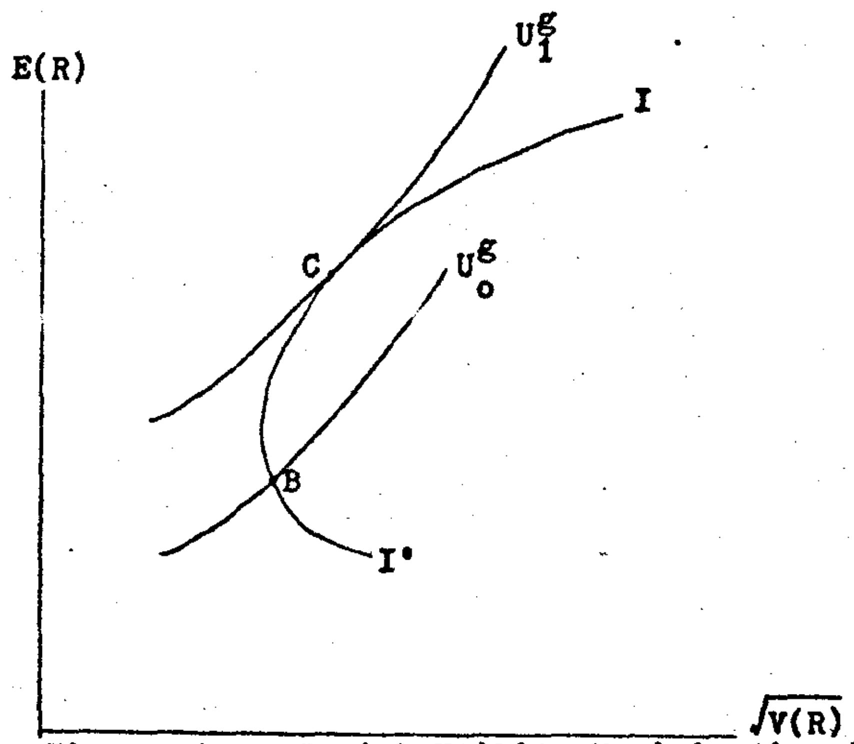

Figure 4a : Social Utility Maximization in the Case where Social Risk Costs are Overestimated by Producers, Model II.

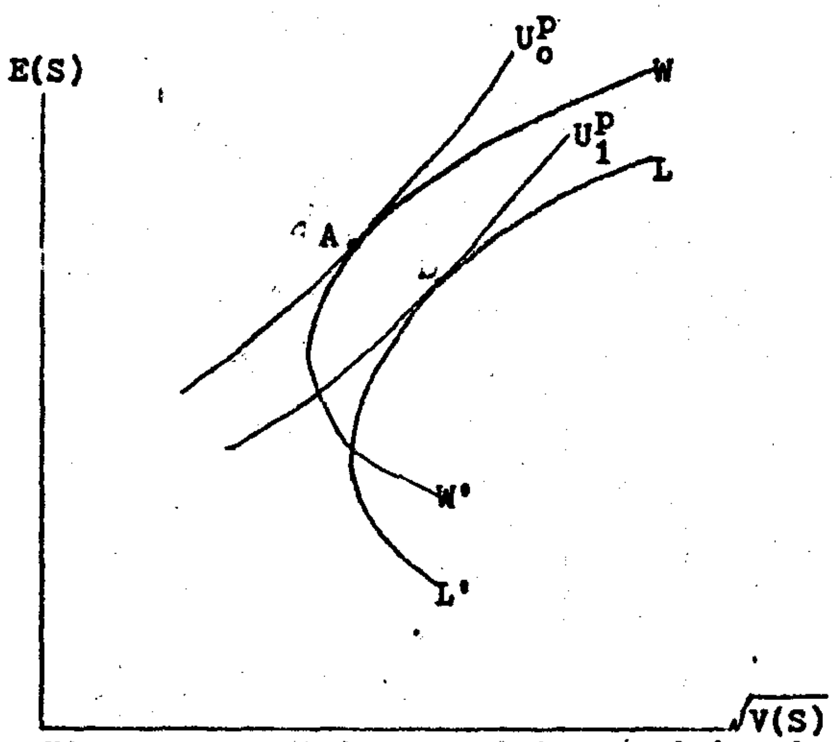

Figure 4b . Private Utility Maximization in the Case where Social Risk Costs are Overestimated by Producers, Model II.

used to encourage more risk-taking and to bring about the simultaneous maximization of private and social expected utility.

V. The effects of export taxes on optimal crop diversification.[20]

We have seen in section IV that export taxes are one of the tools which can theoretically be used to bring the social and private optimal diversification together. But it can be demonstrated that export taxation on any crop will lead to an ambiguous result on the optimal pattern of crop diversification. In this section, by using a simple theoretical framework, we will specifically show that it is not at all clear how crop diversification is affected by an export tax on a food crop. An export tax on a food crop is intentionally chosen for the analysis so that we can determine how the rice premium could conceptually influence the pattern of export crop diversification in Thailand.

To simplify, let us suppose that there are two kinds of crops to be grown on a fixed area of land : a food crop which can either be sold or consumed by a producer and a cash crop which can only be marketed. A proportion of land in growing the food

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[20] Most of the theoretical concepts and conclusions in this section are similar to those in the model by Nowshirvani (10), though our approach is slightly different and our purpose is narrower in scope.

crop is denoted by "a". Since the goal of self-sufficiency is important in the producer's decision in most underdeveloped agriculture, we signify F as a certain fixed amount of food required for on-farm consumption. The production of the food crop beyond F will be a marketed surplus. Uncertainty is assumed to occur only in the prices and yields of both crops, and their variations are independently distributed. For the sake of simplicity, the costs of production are ignored here, so that we do not distinguish between the net and gross income.

Let I = the cash income.

I_f, I_c = the cash income from the sale of the food crop and the cash crop respectively.

P_f, P_c = the farm prices of the food crop and the cash crop respectively.

Y_f, Y_c = the yields of the food crop and the cash crop respectively.

$V(P_f)$, $V(P_c)$ = the variances of the farm prices of the food crop and the cash crop respectively.

$V(Y_f)$, $V(Y_c)$ = the variances of the yields of the food crop and the cash crop respectively.

Then the total cash income is given by

$$I = aI_f + (1-a)\ I_c \quad \text{..................(5)}$$

where $$I_f = P_f\ (Y_f - F) \quad \text{..................(6)}$$

and $$I_c = P_c\ Y_c - P_f\ F \quad \text{..................(7)}$$

The mean and variance of the total cash income in equation (5) are respectively as follows:

$$\bar{I} = a\bar{I}_f + (1-a)\ \bar{I}_c \quad \text{..................(8)}$$

$$V(I) = a^2\ V(I_f) + (1-a)^2\ V(I_c) + 2a(1-a)\ Cov\ (I_f, I_c) \quad \text{....(9)}$$

Where the barred variables represent the mean values, and V and Cov are variance and covariance operators respectively.

The means and variances of I_f and I_c are given by

$$\bar{I}_f = \bar{P}_f\ (\bar{Y}_f - F) \quad \text{..................(10)}$$

$$\bar{I}_c = \bar{P}_c\ \bar{Y}_c - \bar{P}_f\ F \quad \text{..................(11)}$$

$$V(I_f) = V(Y_f)\ \left[V(P_f) + (\bar{P}_f)^2\right] + V(P_f)\ (\bar{Y}_f)^2 + V(P_f)\ F^2 - 2\bar{Y}_f\ FV(P_f) \text{..(12)}$$

$$V(I_c) = V(Y_c)\ \left[V(P_c) + (\bar{P}_c)^2\right] + V(P_c)\ (\bar{Y}_c)^2 + V(P_f)F^2 \quad \text{..............(13)}$$

Substiution equations (10) and (11) in equation (8), and equations (12) and (13) in equation (9) give:

$$\overline{I} = a\overline{P}_f\overline{Y}_f + (1-a)\overline{P}_c\overline{Y}_c - \overline{P}_f F \quad \ldots\ldots\ldots\ldots\ldots\ldots(14)$$

and
$$V(I) = a^2 \left\{ V(Y_f) \left[V(P_f) + (\overline{P}_f)^2 \right] + V(P_f)\ (\overline{Y}_f)^2 + V(P_f)F^2 - 2\overline{Y}_f F V(P_f) \right\} + (1-a)^2 \left\{ V(Y_c) \left[V(P_c) + (\overline{P}_c)^2 \right] + V(P_c)\ (\overline{Y}_c)^2 + V(P_f)^2\ F^2 \right\} + 2a(1-a)\ V(P_f)\ (F^2 - \overline{Y}_f\ F) \quad \ldots\ldots\ldots\ldots(15)$$

Now if the producer is risk-averse as we assume all along, and his utility function of total cash income has the same form as those in the models in section IV, then his expected utility function will be

$$\overline{U} = \overline{I} + \frac{b}{2}\ V(I) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(16)$$

where $b < o$ and is the degree of risk aversion of the producer, and $\overline{I}$ and (V(I) are defined as in equations (14) and (15). The producer will try to choose "a" ---- the proportion of land devoted to the food crop --- such that his expected utility in equation (16) is maximized. Graphically this means that he will produce at a point where his utility-indiference curve touches the efficiency frontier, as U^* touches AA' at point P in figure 5. Thus the effect of an export tax on the optimal diversification can be analysed in terms of its effects on the mean and variance (or standard deviation) of total cash income.

Suppose that only export of the food crop is taxed. It is clear that an export tax such as the rice premium in Thailand will reduce the mean farm price ($\overline{P}_f$) of the taxed crop (i.e. rice in the Thai case). But it is not clear how it affects the variance of the price ($V(P_f)$). Conceiveably, the variance can be increased or decreased or unaffected by the tax.

First let us look at the effect of the tax on diversification through its influence on the mean price, $\overline{P}_f$. We differentiate equations (14) and (15) with respect to $\overline{P}_f$:

$$\partial \overline{I} / \partial \overline{P}_f = a\overline{Y}_f - F \qquad \text{.................(17)}$$

and $$\partial V(I) / \partial \overline{P}_f = 2a^2 \, V(Y_f)\overline{P}_f \qquad \text{.................(18)}$$

Equation (17) is positive if $a\overline{Y}_f > F$, i.e. if the producer, on the average, grows enough food for on-farm consumption. In this case the export tax, which reduces $\overline{P}_f$, will also reduce $\overline{I}$. And since $\partial (\partial I / \partial \overline{P}_f) / \partial a = \overline{Y}_f > 0$, the more food is grown (i.e. the greater the value of "a") the more is the reduction in $\overline{I}$. Thus with self sufficiency in food, the export tax on the food crop will discourage its production through the reduction of $\overline{P}_f$ and $\overline{I}$. When the food requirement exceeds food production, a reduction in $\overline{P}_f$ increases $\overline{I}$, since part of food consumption has to be purchased and a decrease in $\overline{P}_f$ improves the producer's income position. However, since $\partial(\partial I/\partial \overline{P}_f)/\partial a > 0$, the rate of increase in $\overline{I}$ due to a reduction in $\overline{P}_f$ will decline as more land is allocated to food production. Thus in the case of insufficient food production, the export tax on the food crop will also tend to reduce its production. The effect of the tax on the efficiency frontier through $\overline{P}_f$ and $\overline{I}$ is depicted in figure 6a. The points on the portion of the frontier below the exact food sufficiency point ($a\overline{Y}_f = F$) shifts downwards, while those above it move upwards.

The export tax on the food crop will definitely reduce the variance of total cash income because, as seen in equation (18), $\partial V(I)/\partial \overline{P}_f$ is always positive. And since $\partial(\partial V(I)/\partial \overline{P}_f)/\partial a = 4aV(Y_f)\overline{P}_f$ is also positive, the decrease in V(I) is greater the more land is used for food production. It is clear that, as far as the effect through V(I) alone is concerned, the export tax on the food crop will tend to encourage more food production because it reduces fluctuations in total cash income. This effect of the tax on the efficiency frontier via $\overline{P}_f$ and V(I) is shown in figure 6b where the whole frontier shifts to the left in such a way that as more land is used to produce food the more the curve is shifted. Therefore, the total effect of the tax on diversification through its influence on $\overline{P}_f$ is ambiguous, as its effects on $\overline{I}$ and V(I) tend to offset one another.

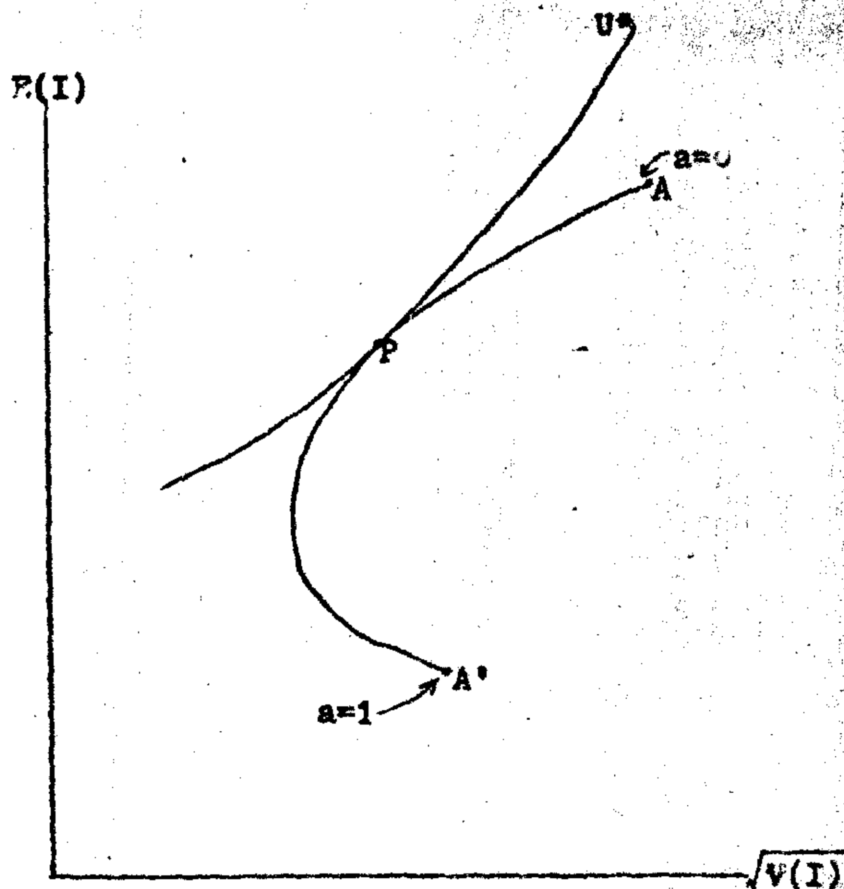

Figure 5: Maximization of Expected Utility Function in a Simplified Two-Crop Model.

Note: The drawing of figure 5 assumes that in the case of complete specialization in either of the crops, (i) $\bar{I}_f < \bar{I}_c$, (ii) $V(I_f) < V(I_c)$, and (iii) the correlation between I_f and I_c is between -1 and 1. Assumptions (i) and (ii) imply that the food crop is a low-risk, low-return crop. But even if these assumptions are changed, the conclusions in this section are still the same.

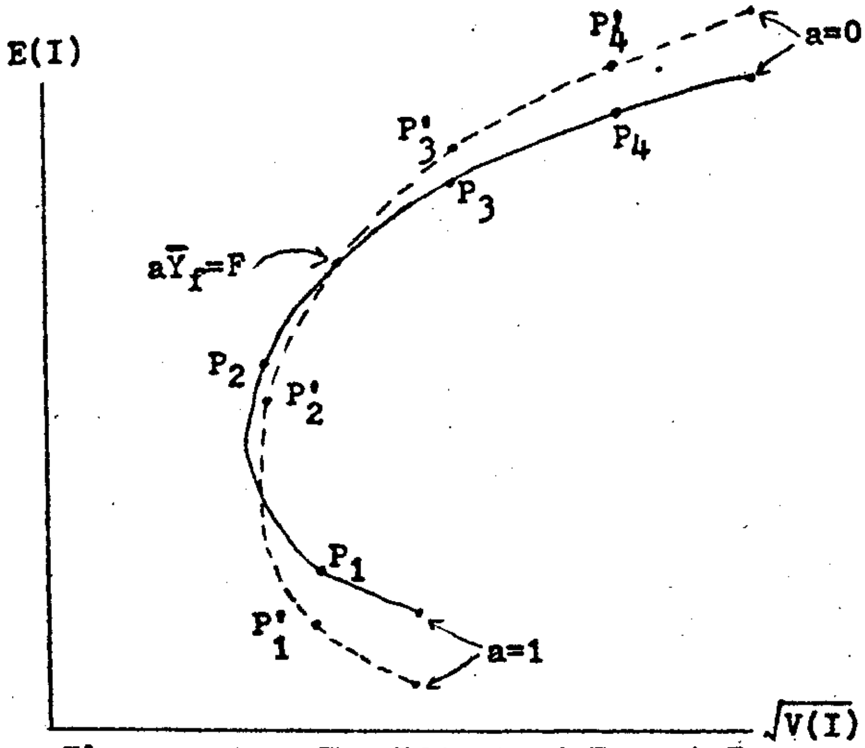

Figure 6a : The Effect of Export Tax on the Efficiency Frontier through $\bar{P}_f$ and $\bar{I}$.

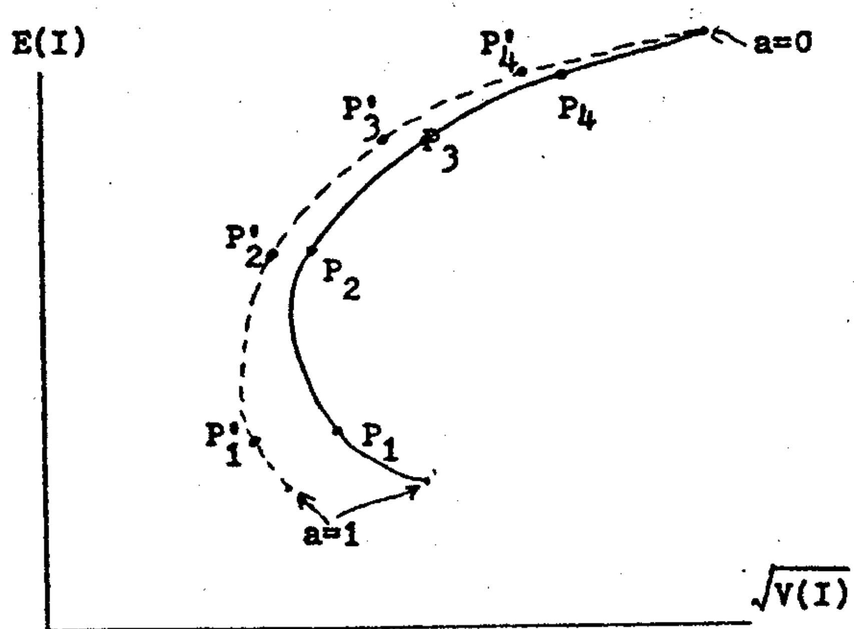

Figure 6b: The Effect of Export Tax on the Efficiency Frontier through $\bar{P}_f$ and V(I).

Note: ______: old efficiency frontier; -----: new efficiency frontier. The crop mixes at P_1, P_2, P_3, and P_4 are the same as those at P_1', P_2', P_3', and P_4' respectively.

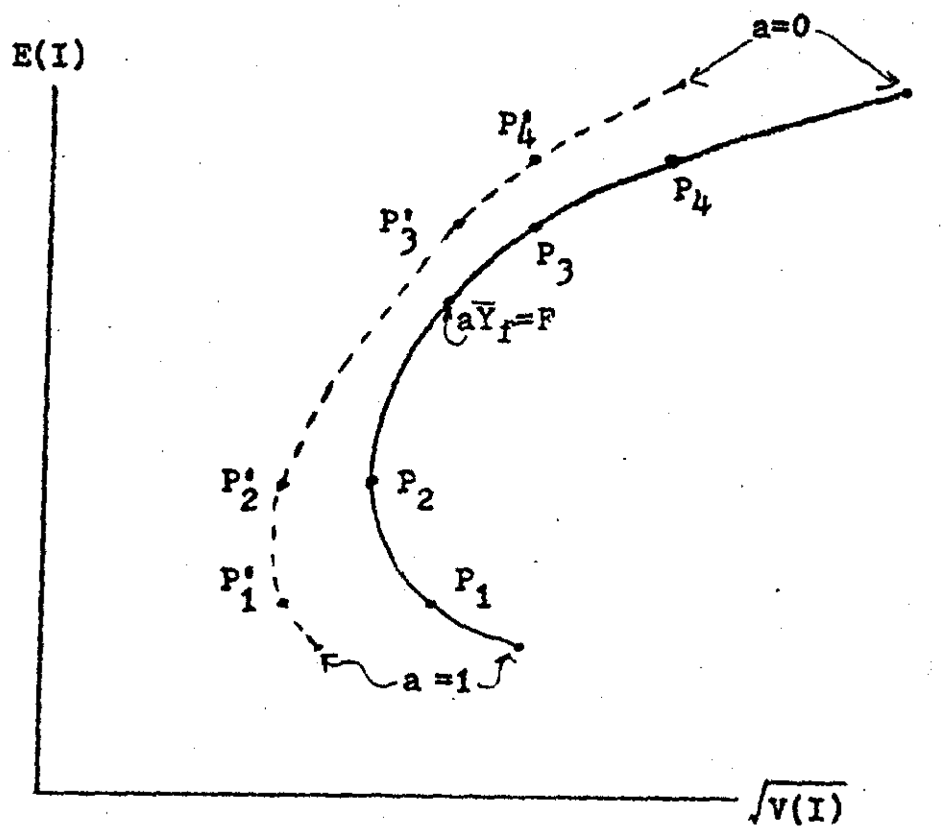

Figure 7 : The Effect of Export Tax on the Efficiency Frontier through $V(P_f)$ and $V(I)$.

Note: _____ : old efficiency frontier;
------ : new efficiency frontier.
The crop mixes at P_1, P_2, P_3, and P_4 are the same as those at P_1', P_2', P_3', and P_4' respectively.

Turning to the effect of the export tax through changes in the variance of food farm prices ($V(P_f)$), we differentiate equations (14) and (15) with respect to $V(P_f)$:

$$\frac{\partial \bar{I}}{\partial V(P_f)} = 0 \quad \text{..................(19)}$$

$$\frac{\partial V(I)}{\partial V(P_f)} = a^2 V(Y_f) + (F - a\bar{Y}_f)^2 \quad \text{........(20)}$$

Equation (19) indicates that changes in $V(P_f)$ do not affect $\bar{I}$. Since equation (20) is always positive, this means that changes in $V(I)$ are in the same direction as those in $V(P_f)$. Suppose now that the export tax reduces fluctuations in P_f, i.e. it decreases the value of $V(P_f)$. Thus the tax will also reduce the size of $V(I)$. But because $\partial\left[\partial V(I)/\partial V(P_f)\right] / \partial a = 2aV(Y_f) - 2\bar{Y}_f (F - a\bar{Y}_f)$ can be either positive or negative or even zero, the rate of reduction in $V(I)$ will differ according to how much land is devoted to food production. For $\partial\left[\partial V(I)/\partial V(P_f)\right] / \partial a$ to be positive, it is necessary that $aV(Y_f) > \bar{Y}_f(F - a\bar{Y}_f)$. This is true if $a\bar{Y}_f > F$, i.e. if the producer is self-sufficiency in food. Hence, the more land is used for food production (i.e. the greater the value of "a"), the greater the rate of decrease in $V(I)$ due to the tax in the food self-sufficiency case. And the tax through this effect alone will tend to encourage food production when enough food is grown. The effect is greater as more land is used in production the food crop.

For $\partial\left[\partial V(I)/\partial V(P_f)\right]/\partial a$ to be negative, we require that $aV(Y_f) < \overline{Y}_f\ (F-a\overline{Y}_f)$. One sufficient, though not necessary, conditon for this to true is when $F > a\overline{Y}_f$ or when food production is less than what is required for on-farm consumption. In this case it is possible that the rate of decrease in V(I) is greater when more land is devoted to cash crop production. Therefore, when some food has to be bought to satisfy on-farm consumption, it is possible that the effect of the tax which reduces $V(P_f)$ and V(I) may be perverse in the sense that it tends to discourage food production even though fluctuations in total income are decreased. The effect of the export tax on the efficiency frontier through changes in $V(P_f)$ is shown graphically in figure 7. There we can see that the efficiency frontier shifts to the new position by different distances. Below the exact food sufficiency point (where $a\overline{Y}_f = F$), the more a point is further from the complete food specialization point (where a = 1), the less it shifts to the left. Above the exact food sufficiency point, the more a point is closer to the cash crop specialization point (where a = 0), the more it shifts to the left.

In the case where the tax increases fluctuations in food prices, all the direction of the effects above are reversed.

The effect of the tax through an increase in $V(P_f)$ alone will tend to discourage food production when where is self-sufficiency in food, but it may perversely cause an increase in food production in the case of a food deficit.

To summarize, we can distinguish two cases: the case where self-sufficiency in food is achieved and the case where some food has to be bought for on-farm consumption. In both cases the effect of the export tax on crop diversification through a reduction in $\overline{P}_f$ is ambiguous. However, the tax effect on crop diversification through a reduction in $V(P_f)$ is likely to encourage food production when food self-sufficiency exists, while it perversely tends to discourage food production when insufficient food is grown.[21] Combining the two types of effect above, we may conclude that if the export tax on the food crop which reduces both $\overline{P}_f$ and $V(P_f)$ has the net effect of increasing food production, the increase is likely to be greater when enough food is produced for on-farm consumption than when it is not. On the other hand, if its effect is to decrease food production, the

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[21] Nowshirvani also examines the case where P_f and Y_f are negatively correlated and concludes that this will only make the perverse effect of food price stabilization (i.e. a reduction in $V(P_f)$) on production even more likely than in the cases examined above. See Nowshirvani (10), pp. 453-5. Thus the inclusion of a negative correlation between P_f and Y_f does not significantly change our conclusion.

decrease is likely to be less when enough food is grown than when it is not. The opposite is true when the tax reduces $\overline{P}_f$ but increase $V(P_f)$. That is, if the net effect is to increase (decrease) food production, the increase (decrease) is likely to be smaller (greater) when there is self-sufficiency in food than when there is a food deficit.

VI. Concluding remarks

The models in section IV indicate theoretically how the government could use export taxes to bring about socially optimal diversification in export crops. But as discussed in section II, it is not *a priori* clear what kind of government intervention is really needed, because there are various factors which require both pro-and anti-risk policy measures. The problem is even more difficult, because, as we show in section V, the effect of a policy instrument such as an export tax on a food crop is not at all obvious. More significant is the fact that the objective of government intervention is not only to achieve diversification in export crops which is socially optimal in terms of net foreign exchange earnings, as indicated in our models above. Other goals pursued by the government are, for example generation of government revenue, better income distribution, and a low cost of living.[22] But even granted that the government aims at the kind of socially optimal export diversification indicated in the models, we may not be able to empirically determine if it is actually maximizing expected social utility as suggeted in our models. This is because such things as the social utility function and the degree of social risk aversion (b) are not easy to derive. Even though we have some knowledge about the degree of private risk aversion (b^*), we may not be able to specualte whether b^* is greater or less than b, because, as indicated before, there is no overwhelming case as to how the two might differ.

However, we are on a firmer ground when we hypothesize that the producers are maximizing the utility function similar to those in the models, since it is reasonable to assume that their objective function depends mainly on their income and is not as

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[22] In the area of government policies concerning rice alone, Timmer and Falcon (6, pp. 397-398) have indenfified eight broad objectives pursued by nine rice-consuming nations in Asia (Burma, Ceylon, Indonesia, Japan, Malaysia, Philippines, South Korea, Taiwan, and Thailand). The objectives are listed as generation of farm income, protection of consumers' welfare, generation of government revenue, generation of foreign exchange, food self-sufficiency, price stability, regional development and equity, and provision of adequate nutrition. Timmer and Falcon also show that the weights assigned to these objectives according to their importance vary from country to country.

multidimensional as that of the government. Therefore, the models are useful as a theoretical framework in which the efficiency production choice facing the producers is derived and their behavior with regard to the production pattern is tested.

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