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Taxes Versus Quotas

The Case of Cocoa Exports

Arvind Panagariya
and
Maurice Schiff

What are the implications of optimal Nash quotas and taxes when two or more countries compete against each other in the world market for primary commodities — in this case, cocoa?

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This paper — a product of the Trade Policy Division, Country Economics Department — is part of the World Bank research project on Commodity Exports and Real Incomes in Africa (RPO 676-70), an effort aimed at analyzing the interactions of commodity exports, real incomes, and trade policies. Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Sheila Fallon, room N10-021, extension 37947 (25 pages).

Panagariya and Schiff are particularly interested in evaluating the concern that efficiency or policy-induced changes in the supply of exports of primary commodities — including cocoa, coffee, and tea — may lead to such a large decline in the prices of those commodities that export revenues and incomes of the exporting countries actually decline. In this paper, they focus on the implications of quantitative restrictions.

They compare the implications of optimal Nash quotas and taxes when two or more countries compete against each other in the world market.

They find that the outcome under taxes is less restrictive than under quotas — but that the countries' profits are higher under quotas than under taxes.

In simulations undertaken for the world cocoa market, they find that for most countries optimal Nash taxes yield lower profits than the initial taxes or quotas. If one of the countries becomes a Stackelberg leader, its profits rise and those of the others fall. But the rise in the Stackelberg leader's profit is lower than the decline in the other countries' profits, so total profits decline.

They also find that even if countries choose taxes or quotas optimally, growth in a country can lead to a decline in the combined real income of the exporting countries.

Their simulations cast doubt on the hypothesis analysts often advance that a market with five or more players can be regarded as roughly perfectly competitive. If this hypothesis were valid for policy formulation in the cocoa market, the optimal export taxes would be about zero. But Panagariya's and Schiff's results indicate that the outcome of the nine-country game is far from the zero-tax solution. So the optimal taxes exceed 10 percent for the largest producers (Côte d'Iveire, Ghana, and Brazil) in the Nash-tax game and in all countries except Indonesia and Oceania in the Nash and Stackelberg quantity games.

Taxes Versus Quotas:
The Case of Cocoa Exports

by
Arvind Panagariya
and
Maurice Schiff*

Table of Contents

1.	Introduction	1
2.	The Model	3
3.	Simulation Results	8
3.1	The Nash Tax Game	10
3.2	Export Quotas: The Nash Quantity Game	11
3.3	Stackerberg-Quantity Game	13
3.4	A Shift in Ghana's Supply Curve	13
3.5	A Shift in Malaysia's Supply Curve	14
4.	Limitations and Future Directions	15
5.	Conclusions	17
References		18
Tables		19
Figures		24

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1. Introduction

This paper is part of an ongoing research effort aimed at analyzing the interactions among commodity exports, real incomes and trade policies. We are particularly interested in evaluating the concern that efficiency or policy induced changes in the supply of exports of primary commodities may lead to such a large decline in the prices of the latter that export revenues and incomes of the exporting countries actually decline.[1] The commodities in question include cocoa, coffee, and tea.

The possibility of income and revenue loss arises principally because the world demand for primary commodities is relatively inelastic. The natural instrument the exporting countries can employ to counteract this problem is trade policy. In doing so one must recognize, however, that since the exporting countries are neither small nor monopolies in the world markets, their policies are interdependent. Because the conventional trade models rely on one of these two extremes, they fail to capture the interdependence of policies central to the problem under consideration.

In our recent work, we have analyzed in detail the implications of interdependence among countries when the policy instrument is an export tax. Thus, in Panagariya and Schiff (1991a), we derive Nash optimum taxes in a 10-country model of the world cocoa market. In our simulations, we find that compared to the initial equilibrium, tax competition implicit in Nash behavior leads to a loss in real income for 8 out of 9 exporting countries.[2] In Panagariya and Schiff (1991b), we compare income and revenue maximizing Nash taxes. A key result in this paper is that under plausible circumstances, revenue maximizing Nash taxes can yield higher levels of income than income maximizing Nash taxes. For example, in the symmetric case, income-maximizing Nash taxes are lower than income-maximizing cooperative taxes and generate a lower level of income than the latter.

[1]See Panagariya and Schiff (1991a) for a documentation of the concerns raised recently. Earlier concerns on these lines had led the World Bank in 1968 to adopt guidelines which severely restricted lending for projects aimed at output expansion of the commodities in question.

[2]As noted in the paper, this and other findings are to be viewed as preliminary. The simulations are based on rough and ready estimates of demand and supply. A more thorough econometric analysis is planned for the future.

Because revenue-maximizing Nash taxes are larger than income-maximizing Nash taxes, they are likely to be closer to the income-maximizing cooperative taxes.

In the present paper, we continue this line of research and focus on the implications of quantitative restrictions. We derive the equilibrium which will result if exporting countries set their export quotas optimally taking the quantities of exports of other countries as given. We compare this equilibrium with the one which obtains when countries use export taxes as the policy instruments. We also perform a number of simulations assuming that countries choose their export quotas optimally in the Nash-Cournot fashion.

We may note at the outset that the equivalence between export quotas and export taxes discussed in the standard trade theory literature (e.g., Bhagwati 1969) will break down in the present context. We know from the recent literature on oligopoly and trade (e.g., Eaton and Grossman 1986) that the equilibria based on price and quantity games exhibit very different properties. The essential point in the present context is that starting at a given initial quantity of the rival's exports, the excess demand curve facing a country is more elastic when the rival imposes an export tax rather than an export quota.[3]

In Section 2, we present a simple demand and supply model and, borrowing from the literature on oligopoly and trade, draw a contrast between equilibria under Nash-Bertrand and Nash-Cournot behavior. In the former case, countries choose their export taxes optimally taking the other countries' tax rates as given. In the latter case, they choose export quotas optimally. We also compare the effects of a movement to Stackelberg behavior by one or more countries under the tax and quota games. Finally, we employ the model to provide an interpretation of the fallacy of composition in the present case.

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[3]We may also note in passing that the nature of our problem is different from that in the conventional retaliation literature a la Johnson (1954), Rodriguez (1974) and Tower (1975). In our paper, two or more countries impose restrictions on goods going to the rest of the world. By contrast, in the literature just cited, two countries restrict exports to <u>each other</u>.

In Section 3, we apply the model to the world cocoa market and derive numerically the optimal taxes and quotas under various behavioral assumptions. We find that the fallacy of composition takes a bigger bite under the Bertrand than under the Cournot game. Implicit tax rates under the quota game are substantially higher than under the tax game. The associated profits are also higher under the quota game. Our simulations for a productivity increase show that it is possible for growth to result in an overall decline in income even if countries choose their taxes or quotas optimally.

In Section 4, we discuss some important limitations of our paper and suggest directions for future research. Summary and conclusions are provided in Section 5.

2. The Model

We employ a simple demand-supply model. All functions are assumed to have a linear form. The world demand is represented by

1) $$Q = A - BP \qquad A, B > 0$$

where P is the price paid by buyers in the world market. Quantity supplied by country i is written

2) $$q_i = a_i + b_i p_i \qquad i = 1, 2 ... n.$$

where p_i is the price received by sellers. Note that the we denote the variables and parameters on the supply side by lower case letters. The difference between P and p_i is accounted for by a quota premium. We denote the quota premium in country i as a proportion of the world price by e_i. Thus,

3) $$p_i = (1 - e_i)P \qquad i = 1, 2, ... n$$

We assume that the government captures the quota premium through either a competitive auction of export licenses, an explicit tax at rate e_i, or by marketing the product itself.

The excess demand facing country j may be written

$$4)\qquad \begin{aligned} Q_j &= Q - \sum_{i \neq j} q_i \qquad\qquad i, j = 1, 2, \dots n \\ &= \left(A - \sum_{i \neq j} q_i\right) - BP \\ &\equiv A_j - BP \end{aligned}$$

Note that A_j in the last equality is a function of the sum of the total quantity supplied by country j 's rivals and hence, in the absence of quotas, of the world price.

We assume that exporters do not consume the good and importers do not produce it. This assumption is valid for cocoa. Each country behaves like a Cournot oligopolist. That is to say, each country maximizes its profits taking the exports of the other countries as given. Therefore, equation (4) represents the perceived demand curve of country j . The corresponding marginal revenue may be written

$$5)\qquad MR_j = \frac{1}{B}(A_j - 2Q_j) \qquad\qquad j = 1, 2, \dots n$$

The marginal cost of production is given by (2). Thus,

$$6)\qquad MC_j = p_j = \frac{1}{b_j}(q_j - a_j) \qquad\qquad j = 1, 2, \dots n$$

At a profit maximizing equilibrium, we have $MR_j = MC_j$ and $Q_j = q_j$. The latter equality simply says that the quantity demanded must equal quantity supplied for country j . Making use of these equalities, (5) and (6) lead to

$$7)\qquad q_j = \frac{b_j A_j + a_j B}{2b_j + B} \qquad\qquad j = 1, \dots n$$

Embedded in (7) are n linear equations in $q_1, \dots q_n$. We can solve these equations for the n equilibrium quantities. Once we have these quantities, equations (1)-(3) can be used to obtain P, p_i and e_i. This is the approach taken in the simulations presented in the next section.

The model outlined above is a standard Nash-Cournot model. Therefore, we do not need to provide an elaborate discussion of its properties. However, it is useful to state briefly some of the properties relevant to the specific problem we are interested in. For this purpose, we concentrate on the duopoly case.

From (7), it is clear that the reaction functions will be linear in the (q_1, q_2) space in the duopoly case. In the symmetric case, we have $a_1 = a_2 \equiv a$ and $b_1 = b_2 \equiv b$ and the equilibrium is characterized by $q_1 = q_2$. In Figure 1 point C, lying on the 45°-line (not shown) through the origin, represents the Cournot equilibrium.

The isoprofit curves for country 1 will be strictly concave to the horizontal axis with a slope equal to 0 at the point where they intersect the reaction curve, R_1R_1 (e.g., see Eaton and Grossman 1986). Intuitively, for a given value of q_2, the corresponding point on R_1R_1 gives the country's best response. Holding q_2 fixed, if the country moves away in either direction from this best-response output, its profits decline. In order to restore profits to the original level, we must reduce q_2 as this will lead to a higher world price. Hence, the isoprofit curves must be flat at the point of intersection with R_1R_1.

As we move down on R_1R_1, profits of country 1 rise. This movement is associated with lower values of q_2 and hence increased market power for country 1. Indeed, at $q_2 = 0$, country 1 becomes the monopolist in the market. Two isoprofit curves, labeled $\pi_1^C\pi_1^C$ and $\pi_1^S\pi_1^S$, are shown in Figure 1.

Country 2's isoprofit curves (not shown in Figure 1) are strictly concave to the vertical axis and have a slope equal to infinity at the points of intersection with R_2R_2. Country 2's profits rise as we move up along R_2R_2. At point M_2 where $q_1 = 0$, country 2 becomes the monopolist in the world market.

As noted earlier, Cournot equilibrium is given by point C in Figure 1. We know from oligopoly literature that one of the two countries could improve its profits position by behaving as a Stackelberg leader. Thus, if country 1 is to behave as the leader, it will export at point S. As expected, its profits will be higher and the follower's profits lower at S than at C.

This result is robust to at least two modifications. First, if the countries are of a different size, Stackelberg equilibrium continues to be superior for the leader and inferior for the follower. For example, an increase in a_1 shifts R_1R_1 to the right in a parallel fashion but does not change the qualitative relationship between Cournot and Stackelberg equilibria.

Second, addition of more countries leaves the above result unchanged. Thus, if there are n countries and one of them acts as a Stackelberg leader, profits and output of that country are higher and those of the other countries lower than at Cournot equilibrium. Essentially, as a Cournot player, each country ignores the fact that an expansion of output by it causes the competitors to contract their output. This pessimistic view leads the country to produce too little relative to Stackelberg equilibrium where it does take into account the rivals' response.

An interesting exception to the above result may arise when we allow a <u>group</u> of countries to act as Stackelberg leaders. Thus, in the linear, symmetric case, if there are 3 players in all and 2 of them jointly become leaders, they produce less than when they act independently as Cournot players. In this case, Stackelberg equilibrium yields a higher profit than Cournot equilibrium even for the follower. This result can be explained in two steps. In the first step, suppose the two countries act jointly as a single Nash player. Their combined output in this case will be less than when they act independently. In the second step, we let the two countries act jointly as Stackelberg leader. This leads to an expansion of output. But this expansion is less than the contraction in the first step. Thus, the net effect of turning the two countries from independent Nash players to joint Stackelberg leader is a contraction of output. This allows the third country to expand its output and profits.[4]

These results contrast sharply with the results obtained from Bertrand competition. Thus, as discussed in Panagariya and Schiff (1991b) in detail, if countries base their decisions taking each other's export taxes as given, reaction functions in the tax rates space are positively sloped. Thus, contrary to the situation depicted in Figure 1, an increased restriction on exports via a higher export tax by the rival causes a country to raise its own export tax. In this setting, it is easy to show that Stackelberg equilibrium is associated with a greater restriction on exports by both the leader and the follower even in a two player game. More interestingly, in the symmetric case, at a Stackelberg equilibrium, profits of the follower are larger than of the leader! This is because starting from Nash equilibrium, the follower increases his tax by less and hence has a larger market share than the leader. These results cannot be obtained when countries choose export quotas strategically.

Another subtle but interesting difference between the two policy instruments is that with taxes, Stackelberg equilibrium is more restrictive than Nash equilibrium while with quotas the opposite is true. Thus with taxes, the world price at Stackelberg equilibrium is higher than at Nash equilibrium. But with quotas, the world price is lower at Stackelberg equilibrium than at Nash equilibrium. This is because in Figure 1, the increase in the leader's output at S relative to C is larger than the reduction in the output of the follower. Hence, joint profits are lower under Stackelberg than under Nash when countries choose quotas strategically, with losses to the follower larger than the gains to the leader.

Before we proceed to the simulation results of the cocoa market, we find it useful to provide an interpretation of the fallacy of composition with the help of Figure 2 which is a modification of

[4]In the general case with n players, the outcome depends on the number of players who jointly become Stackelberg leaders <u>relative</u> to those who remain Nash followers.

Figure 1. We know that the joint profits of the two countries will be maximized somewhere on the segment OC of the 45°-line. Essentially, the output of each country must be less at the joint-profit maximizing equilibrium than at Cournot equilibrium, *C*. Let *J* represent the point of joint-profit maximization. Suppose now that the current exports of the two countries happen to be at point *A*. From *A*, each country can increase its profits by expanding exports towards its reaction function provided the other country keeps its exports at the level indicated by *A*. However, if both countries expand their exports, they will find themselves at point B and make less profits than at *A*. This is the essence of the fallacy of composition.

A final related point to note is that in the example shown in Figure 2, if the countries are initially at B and move simultaneously assuming that the other country will maintain its current output, both countries will reduce their exports and increase their profits. To the extent that an equilibrium is reached only at C and not J, however, an element of the fallacy of composition remains. That is to say, even at the Nash-Cournot equilibrium, countries wind up exporting too much relative to their joint profit maximization levels.

3. Simulation Results

We note at the outset that there are important empirical and theoretical limitations of the simulations reported below. Although we will discuss these limitations in detail in Section 4, we wish to caution at the outset that the results reported below should be considered tentative.

Table 1 provides the information on the initial equilibrium. The first five columns with numbers are self explanatory.[5] The sixth and seventh column are derived from the output, price and

[5]Some small producers, other than the nine appearing in Table 1, have been excluded from the analysis. The implicit assumption is that their supply is fixed and does not respond to the world prices.

elasticity. The elasticities were estimated by their authors assuming constant-elasticity functions. We linearized these functions around the price and quantity shown in Table 1 and applied the elasticity estimates to obtain the slope and intercept shown in the last two columns. The elasticity of demand in the world market used in the simulations is 0.4. Given the price and quantity in 1986, this yields an intercept of 12286.3 Metric Tons and a slope of -315.6 Metric Tons per U.S. dollar.

The elasticities in Table 1 are diverse and require some explanation. For traditional, long-established producers such as Brazil, Côte d'Ivoire, Ghana and Nigeria, elasticities are low while for more recent entrants such as Malaysia and Indonesia they are high. This may be because traditional producers have only limited possibilities with respect to substitution into and out of other crops. In addition, for output expansion, these countries do not have suitable land available at the margin. By contrast, Malaysia and Indonesia have been able to take advantage of vast amounts of suitable virgin land. We hope to shed more light on this issue in our future work where we will attempt a careful estimation of supply elasticities using flexible functional forms.

Using the information in Table 1, we can calculate what we call the "Actual" equilibrium. By virtue of the calibration procedure, this equilibrium is the same as that in Table 1. In Table 2, we show the profits associated with this equilibrium in column 4. These profits include the producers' surplus and tax revenues. Table 2 also provides the output and profits if all restrictions on exports are removed, i.e., if the marginal cost is equated to the world price. Not surprisingly, a total removal of export restrictions lowers the world price (from $2,070 to $1,562 per metric ton) and benefits the importers of cocoa. In principle, countries which tax exports too heavily can experience an improvement in welfare by a movement to free trade but this does not happen in our simulations. Only Ghana which taxed exports in 1982 at the rate of 70% of the world price experiences more or less no change in profits. All other countries experience significant losses from a movement to the free trade equilibrium.

In Tables 3-5, we present several simulations. These include:

1. Each country takes the export taxes of its competitors as given and chooses its own tax rate optimally. This is referred to as Nash (T) game in Tables 3-5 and was analyzed in detail in Panagariya and Schiff (1991a).

2. Each country takes the export quantities of the competitors as given and chooses its own export quantity optimally. This is referred to as Nash (Q) game in Tables 3-5.

3. The largest exporter, Cote d'Ivoire, is Stackelberg leader and the other countries are followers. The countries choose export quantities and play what we call Stackelberg (Q) game in Tables 3-5.

4. Ghana's supply curve shifts to the right by 100,000 Metric Tons. We simulate the effects of this change both under initial quotas and Nash tax and quantity games.

5. Malaysia's supply curve shifts to the right by 100,000 Metric Tons. As in (4), we simulate effects of this change both under initial export quotas and Nash tax and quantity games.

In the following, we discuss each of these simulations in detail and where relevant compare them to each other or to the initial equilibrium.

<u>3.1 The Nash Tax Game</u>: In this simulation, each country chooses its export tax optimally taking the taxes of other countries as given. As shown in columns 1 and 2 of Table 3, the changes from the initial equilibrium are rather dramatic. With the exception of the countries with 0 initial tax and Cote d'Ivoire, Nash taxes for all countries are substantially below the actual levels. For Ghana, Cameroon and Nigeria, the ratio of actual to Nash taxes is especially high at 3, 5 and 8, respectively. Under Nash behavior, countries ignore the fact that a tax reduction by them leads the competitors to do the same and, as a result, act aggressively to capture a larger share of the market. Given a relatively steep world-demand curve, this behavior is accompanied by a sharp decline in the price and only a

limited expansion of the quantity sold. Thus, the decline in the price from the initial equilibrium is 14.1% while the increase in quantity is only 5.6%.

The effects of these changes in taxes, the world price and total quantity are reflected in the changes in real incomes defined as the tax revenue plus producers' surplus and referred to as profits in Tables 2-5. Of the nine countries, only Ghana's real income (profit) is higher in the Nash-tax equilibrium than initially. All the other countries experience a lower profit! Africa as a whole also experiences a lower profit in the Nash-tax equilibrium than initially.

Several African countries and Africa as a whole do gain in terms of output share. The total African output rises by 19.6% yielding a 71.5% share in the world market. The latter is higher than the corresponding share at the initial equilibrium bv 8.3 percentage points. Ghana makes the biggest gain in output: from 219,000 M.T. to 347,000 M.T. This 58% increase in output is the result of reduction in the tax rate from 70% to 19.5% and the fact that Ghana enjoys a cost advantage relative to its competitors.

Tax revenues for Ecuador, Malaysia, Indonesia and Oceania are 0 in the initial equilibrium due to no taxation. For these countries, revenues in the Nash-tax equilibrium are obviously higher. For all the remaining countries revenues decline, however, due to a reduction in the tax rate and limited expansion of quantity. It is striking that even Ghana which gains substantially in terms of output expansion loses on account of tax revenue.

3.2 Export Quotas: The Nash Quantity Game: Next, we consider the case when the countries play a Nash-Cournot game and set export quotas optimally, taking the competitors' export quotas as given. The result in this case, shown in columns numbered 3 in Table 3, stand in sharp contrast to those in the previous case. Most importantly, countries are far more restrictive under the quota game than under the tax game. Remarkably, all countries except Cote d'Ivoire experience a higher real income (profits) in this case than at the initial equilibrium.

It is most interesting to compare the equilibria based on the tax and quota games. Broadly speaking, the Nash-tax outcome is less restrictive and Nash-quantity outcome more restrictive than the initial equilibrium. In terms of Figure 2, assuming symmetry, we can imagine that the initial equilibrium corresponds to B, the Nash-tax outcome to a point farther out along OB and the Nash-quantity outcome to C.

Comparing columns (2) and (3) under the heading "Tax Rates" in Table 3, we note that the implicit tax rates under the quota game are consistently higher than those under the tax game. This result is related to the earlier observation (due to Eaton and Grossman 1986) that in considering tax reductions under the tax game countries are "too optimistic" while in considering output expansion under the quota game they are "too pessimistic." In the former case, a tax reduction by a country is matched by rivals but this is ignored by the country. In the latter case, rivals respond to a quantity expansion by quantity reduction and the country ignores it while choosing its own optimal level of exports.

As expected, the largest exporters -- Cote d'Ivoire and Ghana - are most restrictive under both tax and quantity games. Compared to the initial tax rate, Cote d'Ivoire's tax rate is approximately the same under Nash tax game but twice as high under the quantity game. In each case, its output is lower than the initial output. In the former case, the country loses market share due to tax competition, especially to Ghana. In the latter case, it also loses the market due to a very high implicit export tax of its own.

The restrictive effect under the quota game is so strong that the world price rises by 7.9% relative to its level in the initial equilibrium. This price increase is the result of a greater exploitation of monopoly power by the exporting countries. Combined profits of the countries rise by 13%. Compared to Nash-tax equilibrium, the increase in profits is even larger (32.1%). Interestingly, the quantity game equilibrium is associated with higher profits for every country than the tax-game equilibrium.

Tax revenues follow the same essential pattern as profits. The major exception is Nigeria which experiences a decline in revenues under both games relative to the initial equilibrium. This is due to the fact that Nigeria's initial tax rate at 50% seems to be aimed primarily at raising revenue regardless of real income considerations.

3.3 Stackelberg-Quantity Game: In columns numbered 4 in Table 3, we show the outcome under the assumption that Cote d'Ivoire acts as a Stackelberg leader in a quantity game. The main result here is that Cote d'Ivoire benefits, relative to the Nash-quantity game, at the expense of all other countries. Cote d'Ivoire's exports expand by more than the combined contraction of exports by the followers. The world price falls relative to the Nash-quantity game and Cote d'Ivoire's profits rise. Profits of the followers decline across the board.

We may note that these results are qualitatively different from those obtained in a Stackelberg-tax game. In this latter case, both the leader and followers increase restriction on exports and are better off relative to the Nash-tax game in terms of profits.

3.4 A Shift in Ghana's Supply Curve: In Table 4, we report the effects of a parallel, rightward shift of 100,000 M.T. in Ghana's supply curve under various assumptions about trade policy. Differences among the various cases within this set of simulations are similar to those in the original case (Table 3). Therefore, we do not discuss this comparison; instead, we focus on a comparison of each case with the corresponding case in Table 3; i.e., on the comparative static effect under each equilibrium concept.

Under no tax-policy response (i.e., keeping the tax rates at their initial level), the shift benefits Ghana and hurts all the other countries. This is as expected since the shift represents an exogenous productivity increase in Ghana and is associated with a decline in the world price of cocoa.

Interestingly, the overall gain in profits is only 1.8%; a substantial part of Ghana's gains in offset by losses in other countries.

Under Nash-tax equilibrium, the story is more or less similar in that Ghana continues to gain while other countries lose. The world price declines but by much smaller magnitude than under actual taxes. As a result, the percentage gain in total profits is larger. However, if we compare the post-shock levels of profits under actual and Nash taxes (Table 4, bottom line, columns 1 and 2), we find that profits are lower in the latter case. The shift in Ghana's supply curve is accompanied by an increase in optimal Nash taxes in most but not all countries. Thus, interestingly, the tax rates in Cameroon, Malaysia, and Indonesia decline slightly.

Finally, the results under the Nash-quantity game follow a similar pattern. Ghana's profits increase while those of the other countries decline. Overall profits rise, although by a very small amount.

3.5 A Shift in Malaysia's Supply Curve: The effects of a shift in Malaysia supply curve are shown in Table 5. In the case of existing taxes, the effects are identical to those in the previous simulation for all countries except Ghana and Malaysia. World profits are lower in the present case than when Ghana's supply curve shifts. The reason is that in the present case a high cost producer, Malaysia, expands output while in the other case a low cost producer, Ghana, expands output.

Perhaps the most interesting result in the present case is that the increase in Malaysia's productivity leads to a decline in the total profits under all regimes. Thus, in spite of the fact that countries adjust the taxes and quantities optimally, they fail to escape a decline in their combined real incomes.

4. Limitations and Future Directions

We now describe some of the limitations of our analysis which future research must attempt to overcome. We consider first the empirical limitations and then theoretical issues.

Information on which our simulations are based does not relate to a single year. For example, elasticity estimates have been drawn from various studies and do not relate to the same time period. Prices and quantities which form the basis of the initial, calibrated equilibrium relate to 1986 while tax rates are from the year 1982 (1983 in the case of Brazil). The simulations also suffer from the limitation that the demand and supply functions are assumed to be linear. In models of oligopoly, results may be more sensitive to functional forms than in models based on perfect competition. In particular, along a linear demand curve, the elasticity of demand declines with price. This property does not hold in general and under plausible circumstances, the opposite may happen. In this eventuality, some of the qualitative conclusions discussed in Section 2 may not hold. In future work, we plan to base our simulations on a more careful econometric analysis allowing for flexible functional forms.

On the theoretical front, it is of utmost importance to recognize the implications of the partial equilibrium nature of our analysis. The partial equilibrium framework, employed in a large number of recent simulation studies of optimal policies for oligopoly industries, relies on the assumption that the sector under study is not sufficiently large to affect the prices in the rest of the economy. However, if the sector is large enough to warrant the analysis of optimal policies, it is likely to be large enough to influence the rest of the economy. This means that the general equilibrium aspects of the present problem, and presumably of the various oligopoly studies, could be potentially important.

The key problem which deserves emphasizing is that if the rest of the economy is distorted, moving one sector in isolation towards its partial-equilibrium optimum is not necessarily welfare improving. The most serious implication of this point for our analysis is that within the standard Walrasian model with balanced trade, restrictions on imports act as substitutes for restrictions on exports via the Lerner Symmetry theorem. Indeed, if import restrictions are sufficiently high and the Lerner Symmetry holds, it may be optimal to impose no restrictions on exports or even subsidize them.

This point raises the natural question as to whether the current levels of import restrictions in some of the cocoa exporting countries are sufficiently high that these countries will benefit from further reductions in export taxes even if such reductions are carried out by all of them jointly. Given the high levels of import restrictions in many of these countries, this might seem highly plausible. Yet, the example of the International Coffee Agreement (ICA) suggests that the issue is more complicated. Despite the fact that some of the coffee exporting countries have had a highly restrictive import regime, the conventional wisdom is that the ICA was beneficial for coffee-exporting countries. Indeed, the general consensus appears to be that the ICA resulted in substantial transfers in real incomes from coffee importing to coffee exporting countries.

A resolution of these conflicting observations may lie in the possibility that the assumptions required for the validity of the Lerner Symmetry theorem fail to obtain in reality. The theorem requires that trade balance be fixed exogenously and is derived from a model in which the nominal exchange rate plays no role even in the presence of nontraded goods. If trade balance is endogenous and is affected by nominal devaluation, however, the symmetry will break down. A 10 percent devaluation is equivalent to a 10 percent import tariff combined with a 10 percent export subsidy. If the Lerner Symmetry theorem is valid, the tax and subsidy should neutralize each other, implying neutrality of the exchange rate. Yet, in most practical situations, it is difficult to imagine that the nominal exchange rate has no effect on the economy.

If one believes that the exchange rate matters, an import tariff is likely to have a smaller effect on exports than an equivalent export tax. The reason is that in the former case, resources will be drawn out of the nontradable sector as well as the exportable sector. By contrast, in the latter case, the exportable sector will lose resources to the importable as well as the nontradable sector.

This point blunts somewhat the force of the Lerner Symmetry argument but the broader proposition that general equilibrium effects may be important for our analysis remains valid. Future research must take this factor into account.

5. Conclusions

We now turn back to the results of our paper. We have compared the implications of optimal Nash taxes and quotas in a setting when two or more countries compete against each other in the world market. We have found that the outcome under taxes is less restrictive than under quotas. However, profits of the countries are higher under quotas than those under taxes. In the simulations undertaken for the world cocoa market, we find that for most countries, optimal Nash taxes yield lower profits and optimal Nash quotas yield higher profits than the initial taxes or quotas. We have also seen that if one of the countries becomes a Stackelberg leader, its profits rise and those of the others fall. The rise in the former's profit is lower, however, than the decline in the latter's profits. Thus, total profits decline. Finally, we have found that even if countries choose taxes or quotas optimally, growth in a country can lead to a decline in the combined real income of the exporting countries.

In conclusion, we note that the simulations in this paper cast doubt on the hypothesis, advanced frequently by analysts, that a market characterized by five or more players can be regarded as approximately perfectly competitive. If this hypothesis were valid for policy formulation in cocoa market, the optimal export taxes would be approximately zero. Our results indicate, however, that the outcome of the nine-country game is far from the zero-tax solution. Thus, the optimal taxes exceed 10 percent for the largest producers (Cote d'Ivoire, Ghana and Brazil) in the Nash-tax game and in all countries except Indonesia and Oceania in the Nash and Stackelberg quantity games.

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Table 1: Basic Data

	Output (000MT)	Output Share (%)	Export Tax[a] (%)	Domestic Price (US$/MT)	Elasticity[b]	Slope[c]	Intercept (000MT)
Cote d'Ivoire	585	35.8	25.1	1550	1.15	0.454	-87.7
Ghana	219	13.4	70.0	621	0.71	0.250	63.5
Cameroon	118	7.2	40.0	1242	1.81	0.172	-95.6
Nigeria	110	6.7	50.0	1035	0.45	0.048	60.5
Malaysia	125	7.7	0.0	2070	3.00	0.181	-250.0
Indonesia	32	2.0	0.0	2070	3.00	0.046	-64.0
Oceania	30	1.8	0.0	2070	3.00	0.043	-60.0
Ecuador	85	5.2	0.0	2070	0.28	0.011	61.2
Brazil	329	20.1	20.0	1656	0.58	0.115	138.2

(a) The non-zero export tax rates are from Imran and Duncan, Table 7, page 21, and refer to 1982 and 1983 (for Brazil).

(b) The long-run elasticities for Brazil, Cote d'Ivoire, and Malaysia were obtained from Akiyama and Bowers, page 25. They apply to ten-year periods, using the highest production levels to obtain those values. We assume that the elasticities of Indonesia and Oceania are equal to that of Malaysia. The other elasticities are from Behrman.

(c) The slope is the change in metric tons for a one US dollar change in the domestic producer price.

Table 2: Initial Results with Actual Taxes and Free Trade

	Tax Rates (%)	Output (000MT)		Profit[1] (Millions of US dollars)	
	Actual (1)	Actual (2)	Free Trade (3)	Actual (4)	Free Trade (5)
Country					
Cote d'Ivoire	25.1	585	590	698	401
Ghana	70.0	219	454	405	404
Cameroon	40.0	118	171	138	86
Nigeria	50.0	110	134	202	152
Africa		1032	1349	1443	1043
Malaysia	0.0	125	33	43	3
Indonesia	0.0	32	8	11	.7
Oceania	0.0	30	7	11	.6
Ecuador	0.0	85	78	151	109
Brazil	20.0	329	318	523	356
World		1633	1793	2182	1512.3

World Price (U.S. dollars/MT)

Actual: 2,070
Free Trade: 1,562

[1]Profits are defined to include producers' surplus and government revenue. Actual profits are derived by assuming that the calibrated demand and supply curves are tru demand and supply curves. These profits will be different in general from actual observed profits (inclusive of tax revenues).

Table 3: Actual, Nash and Stackelberg Equilibria

Initial Results

Actual: A; Nash Tax Game: Nash (T); Nash Quantity Game: Nash (Q); Stackelberg Quantity Game: S(Q)

	Tax Rates (%)				Output (000 MT)				Profit (millions of US$)				Revenue (millions of US$)			
	A	Nash (T)	Nash (Q)	S(Q)	A	Nash (T)	Nash (Q)	S(Q)	A	Nash (T)	Nash (Q)	S(Q)	A	Nash (T)	Nash (Q)	S(Q)
Country	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Cote d'Iv.	25.1	25.2	52.7	29.5	585	490	371	539	698	496	595	659	304	220	436	324
Ghana	70.0	19.5	49.3	49.7	219	421	347	321	405	493	614	523	318	146	382	326
Cameroon	46.0	8.2	26.4	25.6	118	184	186	165	138	125	210	165	98	27	109	[illegible]
Nigeria	50.0	5.7	20.5	21.[illegible]	110	139	144	136	202	182	247	218	114	14	66	59
Africa					1032	1234	1048	1161	1443	1296	1666	1565	834	407	993	795
Malaysia	0.0	2.8	13.9	11.9	125	63	98	76	43	14	57	35	0	3.2	30	19
Indonesia	0.0	0.7	4.8	4.1	32	17	34	26	11	3.4	16	10	0	.2	3.6	2.2
Oceania	0.0	0.6	4.5	3.8	30	16	32	25	11	3.2	15	9	0	.2	3.2	1.9
Ecuador	0.0	3.2	11.8	12.6	85	80	83	81	151	126	164	148	0	4.6	22	20.7
Brazil	20.0	13.4	41.1	42.4	329	315	289	274	523	424	547	480	136	75	266	237
World					1633	1725	1584	1643	2182	1866.6	2465	2247	970	490.2	1317.8	1075.8

World Price (U.S. Dollars/MT)
Actual = 2,070
Nash (T) = 1,779
Nash (Q) = 2,233
S (Q) = 2,046

Table 4: Effects of Increasing Ghana's Intercept by 100,000MT at Various Equilibria

Actual: A; Nash Tax Game: Nash (T); Nash Quantity Game: Nash (Q)

	Tax Rates (%)				Output (000 MT)				Profit (millions of US$)				Revenue (millions of US$)		
	A	Nash (T)	Nash (Q)		A	Nash (T)	Nash (Q)		A	Nash (T)	Nash (Q)		A	Nash (T)	Nash (Q)
Country	(1)	(2)	(3)		(1)	(2)	(3)		(1)	(2)	(3)		(1)	(2)	(3)
Cote d'Iv.	25.1	25.3	52.6		560	470	361		642	460	565		280	205	414
Ghana	70.0	23.5	57.5		313	492	395		579	631	755		437	200	496
Cameroon	40.0	8.1	26.2		109	175	180		121	114	197		87	24	103
Nigeria	50.0	5.8	20.6		107	137	142		191	173	239		107	14	64
Africa					1089	1274	1078		1533	1378	1756		911	443	1077
Malaysia	0	2.5	13.4		111	53	92		34	10	50		0	2.3	27
Indonesia	0	0.6	4.6		28	15	32		8.3	2.5	14		0	.2	3.2
Oceania	0	0.6	4.3		26	14	30		7.7	2.3	13		0	.1	2.8
Ecuador	0	3.3	12.0		83	79	82		144	122	159		0	4.6	22
Brazil	20.0	13.7	41.5		322	309	285		495	405	528		128	73	258
World					1659	1744	1599		2222	1919.8	2520		1039	523.2	1390

World Price (U.S. Dollars/MT)
Actual = 1,993
Nash (T) = 1,722
Nash (Q) = 2,182

Table 5: Effects of Increasing Malaysia's Intercept by 100,000MT at Various Equilibria

Actual: A; Nash Tax Game: Nash (T); Nash Quantity Game: Nash (Q)

	Tax Rates (%)			Output (000 MT)			Profit (millions of US$)			Revenue (millions of US$)		
	A	Nash (T)	Nash (Q)	A	Nash (T)	Nash (Q)	A	Nash (T)	Nash (Q)	A	Nash (T)	Nash (Q)
Country	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Cote d'Iv	25.1	25.2	52.6	560	470	360	642	457	561	280	203	411
Ghana	70.0	19.7	49.4	213	408	338	380	463	585	297	138	364
Cameroon	40.0	8.1	26.1	109	174	179	121	113	195	87	24	102
Nigeria	50.0	5.8	20.7	107	136	142	191	172	238	107	14	64
Africa				989	1188	1019	1334	1205	1579	771	379	941
Malaysia	0	6.6	22.6	211	140	155	123	70	142	0	16	76
Indonesia	0	0.6	4.6	28	14	31	8.3	2.4	14	0	.1	3.1
Occania	0	0.6	4.3	26	13	29	7.7	2.2	13	0	.1	2.8
Ecuador	0	3.3	12.0	83	79	82	144	121	159	0	4.5	21.5
Brazil	20.0	13.7	41.5	322	309	284	495	404	525	128	73	257
World				1659	1743	1600	2112	1804.6	2432	899	472.7	1301.4

World Price (U.S. Dollars/MT)
Actual = 1,993
Nash (T) = 1,717
Nash (Q) = 2,174

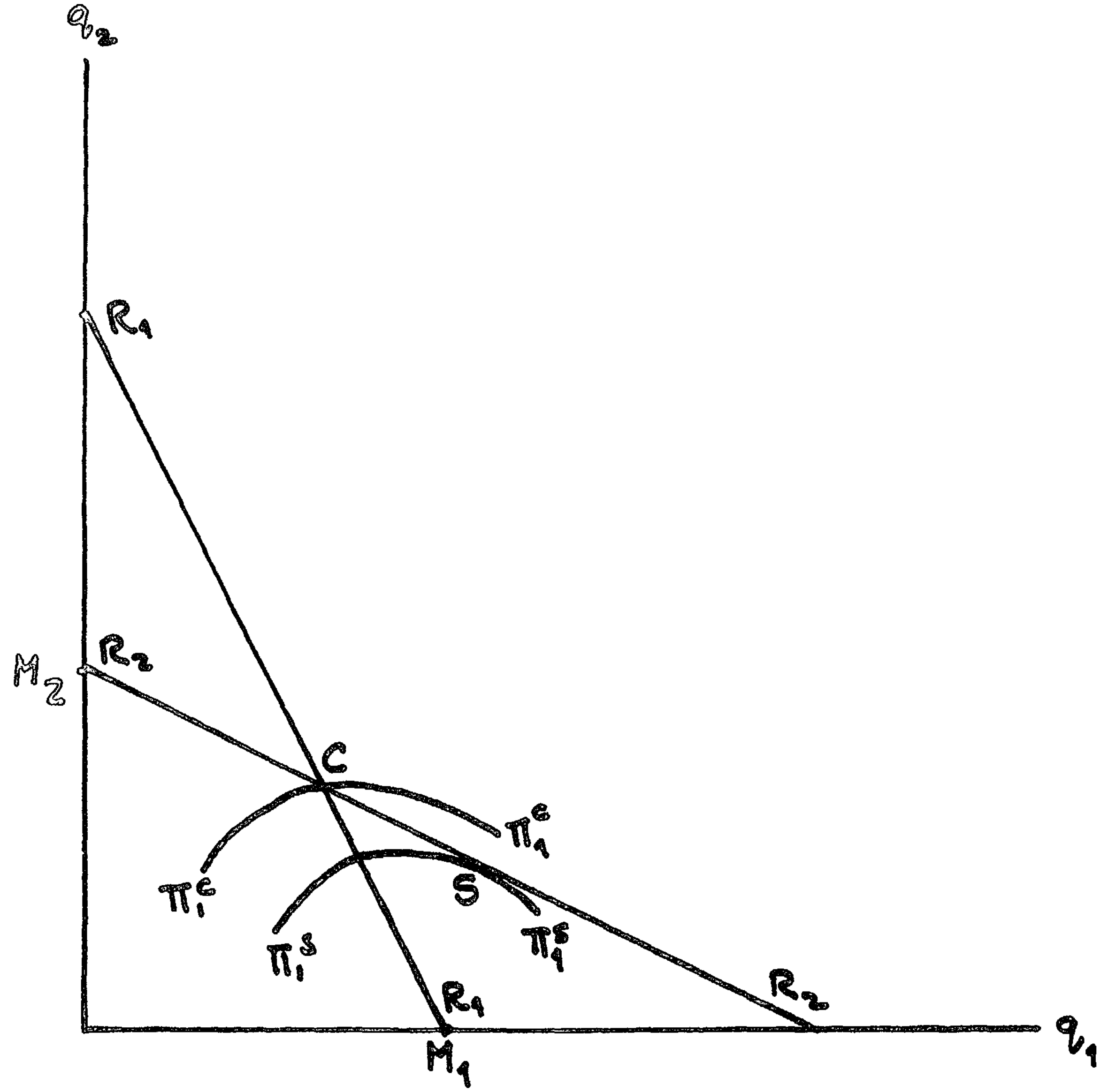

Figure 1

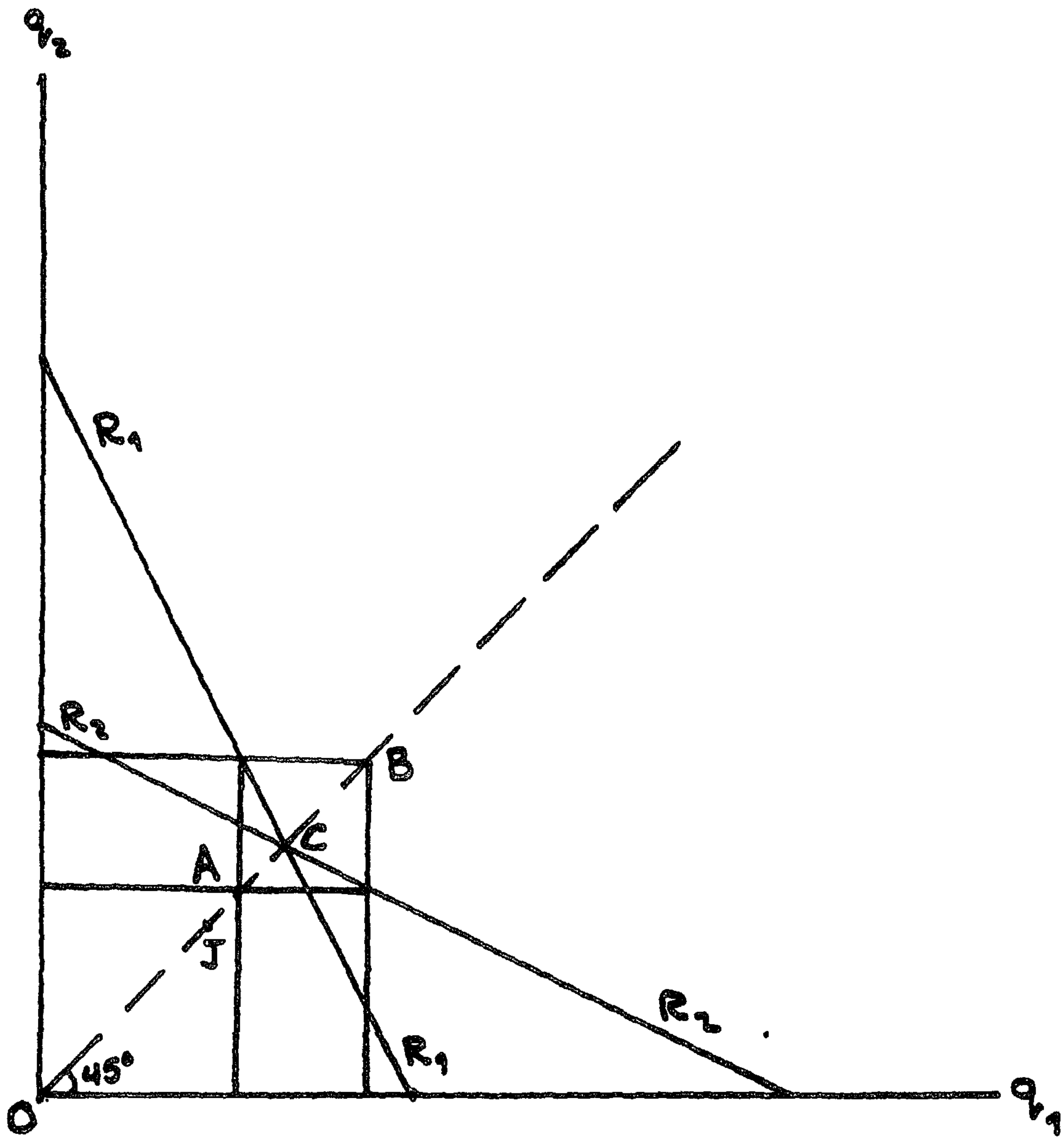

Figure 2

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