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EFFECTS OF MINERAL DEVELOPMENT ON THE ECONOMY*

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R. G. Gregory's article on the effects of mineral discoveries on the Australian economy (*Australian Journal of Agricultural Economics*, August 1976) has attracted much attention. While the partial-equilibrium nature of his model has enabled it to be absorbed readily, it has the usual theoretical limitations of such analyses.

Allowing for general equilibrium repercussions, but still accepting his general assumptions, some of Gregory's conclusions regarding the impact of new mineral discoveries require modification or extension:

(a) Although production of goods other than minerals can be expected to decline, the production of some goods in this category may rise;

(b) A social gain is still possible even if outputs of other goods do not change;

(c) While the price of non-tradeable goods can be expected to rise, production of non-tradeables may increase or decrease.

We also show the magnified effect of mineral discoveries on the rents of factors specific to minerals, and the squeeze exerted on the rents of factors specific to other tradeables.

I Introduction

With unusual success, Bob Gregory (Gregory 1976) has captured the attention of the economics profession and the financial press in analysing the impact of mineral development on the Australian economy. The essence of his model is that mineral discoveries lead to an increase in export supply and that this brings an external surplus. The correction of this surplus by currency revaluation or by domestic inflation raises the price of non-tradeable goods relative to the price of exports and imports. As a consequence import-competing and pre-existing export industries are squeezed. The model is simple and appears to explain some of the difficulties experienced by import-competing industries in recent years.

Gregory's basic model is reproduced in Figure 1. The relative price of traded to non-traded goods is shown on the vertical axis. It is assumed that there are constant international terms of trade and that import-competing goods are perfect substitutes for imports. Thus with given tariffs, export subsidies, etc., the relative prices of imports, import-competing goods, exports and exportables consumed domestically are

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all constant. On the horizontal axis the quantities of exports and imports are measured; units are chosen so that a unit of exports exchanges for a unit of imports. The curves X_0 and M_0 indicate the supply of exports and the demand for imports, respectively, at various price ratios, prior to the mineral discovery. With constant international terms of trade all exports which are offered at a given price will be purchased and all imports demanded will be supplied at a constant price; thus X_0 and M_0 can be regarded as showing actual exports and imports. Exports equal imports at the intersection of the two curves. Allowance can easily be made for capital flows so that overall external balance can be shown, but it is simplest to assume zero net capital movements. The upward slope of

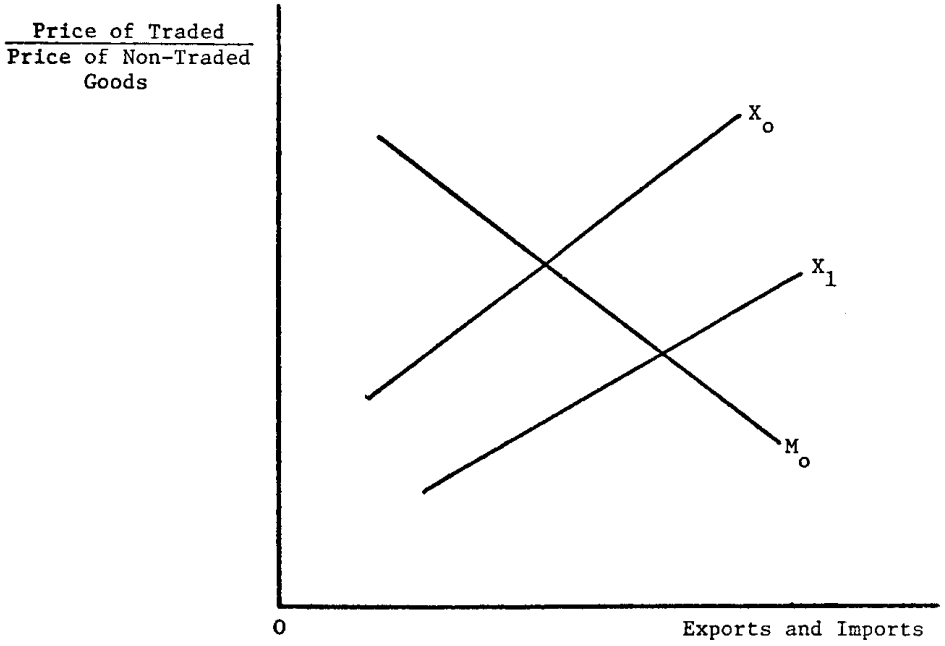

FIGURE 1

X_0 derives from the increased profitability of producing export goods as the traded to non-traded price ratio rises and also from the decreased domestic demand, as this price rises, for goods which could be exported. The downward slope of M_0 reflects the increased demand for importables (imports and domestically-produced substitutes), and the reduced profitability of producing substitutes domestically, as the price ratio falls.

With mineral discoveries, the export curve shifts to the right to X_1, leading to a lower equilibrium traded/non-traded price ratio and increased exports and imports; as indicated, domestic inflation or exchange rate revaluation could change the price ratio in the required manner. Gregory argues that both import-competing industries and pre-existing exporting industries will be reduced in size and that 'The adjustments that need to be made depend on the extent of the mineral discoveries, the price elasticity of supply of minerals exports and the price elasticity of demand and supply of imports and traditional exports.' (Gregory, p. 77.) He then undertakes a number of calculations of the

relevant elasticities, etc., and the price adjustments required to accommodate the Australian mineral boom.

Gregory's thesis is an important one and he has shown great ingenuity in applying it. However, there are some difficulties associated with it. Apart from questions relating to the time period over which adjustment may occur, the difficulties spring from the partial equilibrium nature of his model. His import and export curves are not shifted as aggregate income and, hence, total demand changes. Again, the impacts of the mineral development on the *costs* of import-competing and pre-existing export industries are not considered. In short, general equilibrium questions are being considered and partial equilibrium tools, like Figure 1 and supply and demand elasticities that ignore the income and cost effects of mineral development, cannot handle them adequately. Of course the analysis will not mislead greatly if the effects taken into account are very strong relative to those omitted. However, it is difficult to accept that an export development that is judged large enough to have a significant effect on the balance of payments would not also have a significant effect on national income, on costs (as well as prices) of other industries and on the demand for imports.

In passing it may be noted that Gregory's model has much in common with the 'Aukrust', 'EFO' or 'Scandinavian' model of inflation (see, for example, Edgren *et al.* 1973), which has gained considerable attention in recent discussions of sources of inflation. In this model it is also assumed that a division can be made between tradeables and non-tradeables, that the country is small so that it cannot affect the international terms of trade, and that the tradeables sector is the main source of productivity growth. This growth corresponds analytically to the mineral developments in Gregory's model. The growth requires an increase in the price of non-tradeables relative to tradeables. At a constant rate of exchange and given international terms of trade this changed price ratio can only be secured by the price of non-tradeables rising in money terms—that is, with a period of domestic inflation. If the rest of the world is inflating or revaluing, so that the price of tradeables is rising, then the price adjustment requires more rapid inflation in the country being considered.

In the following sections, simple general equilibrium models are developed to explore the consequences of mineral development. Like Gregory, a 'before and after' or comparative static analysis is adopted. In effect this assumes that the development is rapid enough for the 'other things being equal' assumption to be made. In Section IV the paper extends beyond the questions attacked by Gregory.

II All Goods Tradeable

We start by assuming an even simpler model than Gregory's, one in which all goods are tradeables. They are divided into two categories, Minerals and Other Goods, the latter comprising exportables other than minerals, imports and the domestic production of import-competing goods. Constant international terms of trade are assumed.

In Figure 2 the (equal) slopes of PP, $P'P'$ and P^*P^* indicate the fixed price ratio between the two categories of goods. The mineral discoveries will increase the productivity of labour and capital in the mineral sector; the shift of the production transformation curve from AB to AB' reflects

this. Point Q indicates the optimum production point before the discoveries while Q' is the optimum after the discovery. Could Q' lie north of Q, so that 'Other Good' production *increases*?

Consider what may be thought of as a limiting case, this being that the effect of the mineral discovery is to increase the production of Minerals by the same amount at all levels of 'Other Good' production.[1] In other words, the size of the increased production of minerals is not a

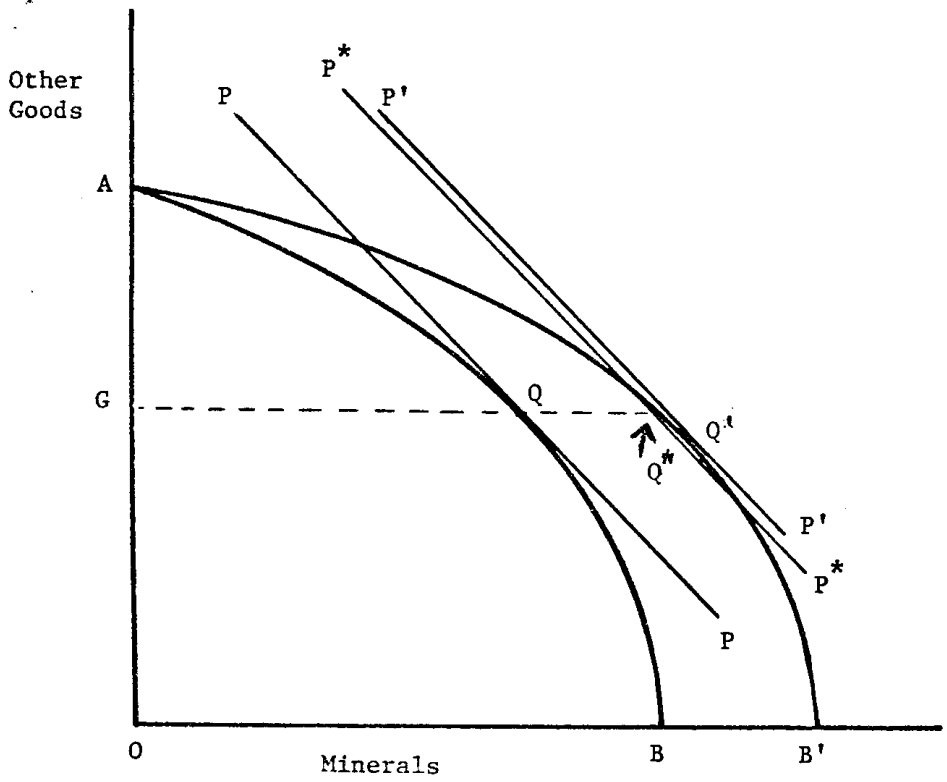

FIGURE 2

function of the inputs of factors other than the mineral resource itself. Under this assumption the production possibility curve shifts horizontally by the same amount at each point. At a point due east of Q on AB', the slope of AB' would be the same as that of AB at point Q. In this case there would be unchanged production of 'Other Goods' at the given terms of trade. If, however, the increased output of minerals *is* related to the use of factors of production, so the horizontal gap between AB and AB' *increases* as 'Other Good' production declines (as illustrated in Figure 2), then the efficient production point Q' will be southeast from Q. This occurs because with the 'gap' increasing, the marginal opportunity cost of producing minerals, at any given level of 'Other Good' production, is decreased. Thus at any given price ratio it will be

[1] Such a change appears unrealistic in the region of point A in Figure 2, for it implies a horizontal section of the new transformation curve from this point, but we are not really concerned with what happens in the region of complete specialization. Note that nothing is assumed regarding the nature of production functions except that there are increasing opportunity costs for each category of goods. It is also assumed that marginal social costs are equated to prices.

profitable to use more mobile factors in mineral, rather than 'Other Good' production. Hence it is unlikely that 'Other Good' production would rise. Although the model here is simpler than Gregory's in that there are no non-tradeables, the conclusion supports him.

However, we may note:

(i) That even though it is likely that production of 'Other Goods' as a whole would fall, contrary to Gregory the production of *some* goods within this category could rise even if their relative prices do not change; thus the production either of exportables other than minerals or of importables could increase, the increase of one being outweighed by the decrease of the other. The differing effect could come through the cost side. To illustrate, suppose that mineral production prior to the discovery had been fairly labour intensive but the newly discovered deposits lead to a substitution of capital for labour and lower the demand for labour. Other industries could now hire labour more cheaply than before and may increase their production. This possibility is overlooked by a partial-equilibrium analysis.

(ii) That even if production of 'Other Goods' is prevented from changing by policy, there is still a gain from development of the mineral resource. This is contrary to the suggestion (Gregory 1976, p. 77) that production of 'Other Goods' must contract so that the gains from mineral development may be secured. The point may be illustrated by viewing PP in Figure 2 as an 'availability of goods' frontier. Points between PP and the origin are achievable, those beyond PP are not. Point Q is the optimal production point and trade may occur 'along' PP, with the domestic consumption point being determined by demand. If 'Other Good' production was retained at its original level of OG, so that the production point on AB' is Q^*, then the availability frontier would be P^*P^*. There is still a gain from the mineral development, though not as great a gain as would have been obtained by letting 'Other Good' production contract so that Q' is the production point and $P'P'$ the availability frontier.

III Non-Tradeables Introduced

We now introduce another category of production, non-tradeables. Rather than attempt three-dimensional representation, we join importables and exportables (including minerals) into a composite good, again using the assumption of given international terms of trade, and introduce non-tradeables as a second good. Again the mineral discovery shifts the production frontier. As the tradeable/non-tradeable price ratio may alter, it is necessary to introduce demand to determine a production point; this is done in the usual way with a community preference map, the derivation of which is unspecified.

What will happen to the price ratio and to the production of tradeables and non-tradeables? On what appear to be very reasonable assumptions we can establish:

(a) that tradeable production will increase;
(b) that the price of non-tradeables will increase;
(c) that the production of non-tradeables could increase *or* decrease.

The conclusions (a) and (b) are consistent with those of Gregory's partial equilibrium analysis, but the third conclusion is not consistent

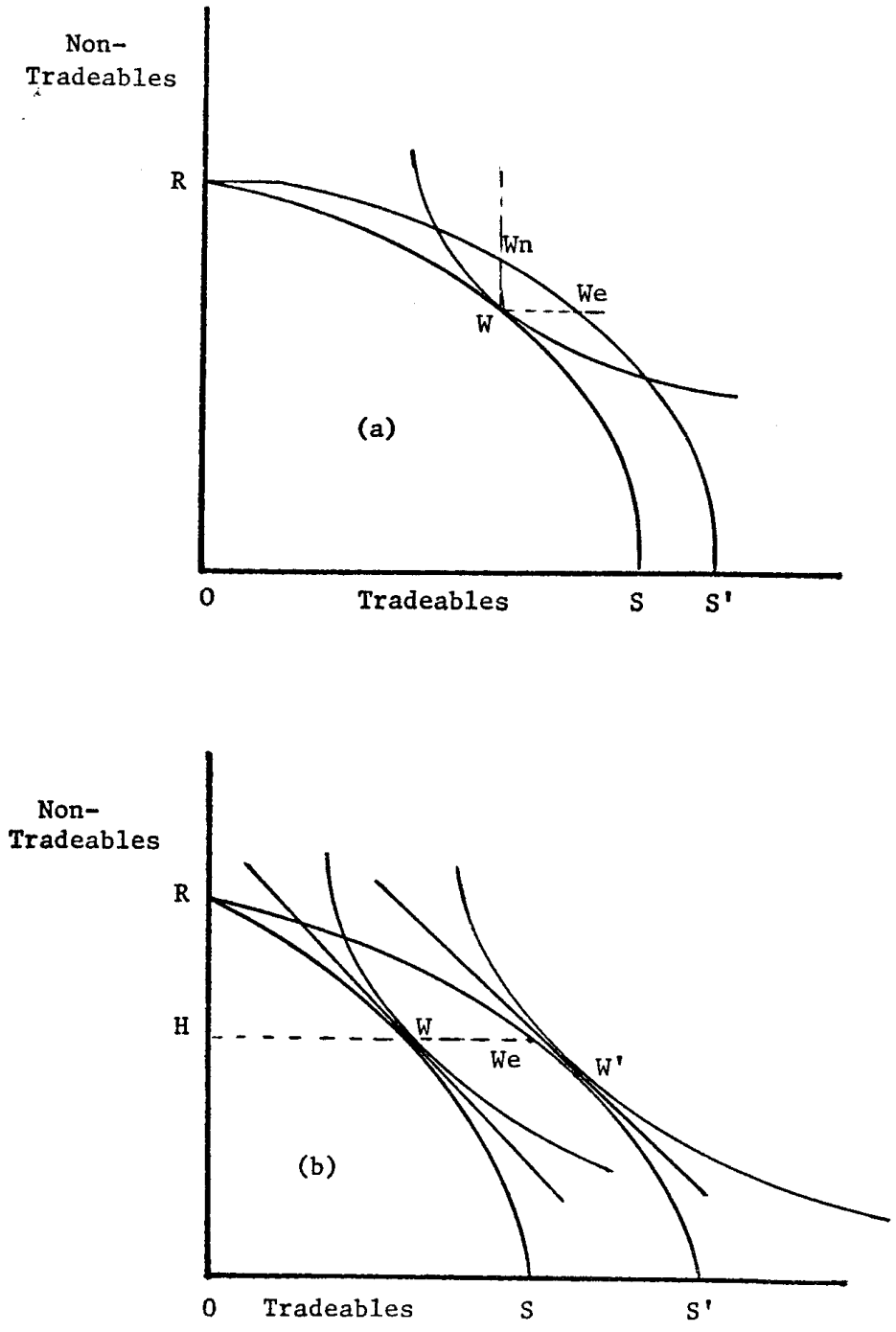
Non-
Tradeables
R
Wn
We
W
(a)
0
Tradeables
S
S'
Non-
Tradeables
R
H
W
We
W'
(b)
0
Tradeables
S
S'

FIGURE 3

with his suggestion (p. 78) that the size of sectors will change in the same direction as prices.

To explain these points, consider Figure 3. As a consequence of mineral discoveries the production frontier for tradeables and non-tradeables shifts from *RS* to *RS'*. Initially, consumption and production are at *W*. If the increase in tradeables production is the same at all levels of non-tradeables production (as in Figure 3(a)) then the marginal cost of tradeables is unchanged at any given level of non-tradeables production, and the slope of *RS'* at a point due east of *W* (i.e. *We*) will be the same as the slope of *RS* at *W*. At all 'higher' points along *RS'*, the slope will be flatter. Unless non-tradeables are inferior goods their price will rise and thus the new equilibrium must be above *We*. However, it will not be above *Wn*, a point due north of *W*, unless *tradeables* are inferior goods, for such a movement would imply a reduction in the consumption of tradeables despite their lower price. Thus, excepting inferiority, the new equilibrium will be confined to the segment of *RS'* that is 'north-east' of *W*, i.e., between *We* and *Wn*.

However it appears more likely that the *increase* in minerals and tradeables production will be greater, the greater the quantity of mobile factors of production that are used in minerals. This implies that the increase in tradeables production would be *inversely* related to non-tradeables production. This case is illustrated in Figure 3(b). Here it is possible for the new equilibrium to be 'south' of *We* along *RS'* (e.g., at *W'*). This may occur even when one retains the assumption of non-inferiority of non-tradeables, for the slope of *RS'* at *We* (and for some distance below *We*) in Figure 3(b) is flatter than that of *RS* at *W*. That is, there could be reduced production of non-tradeables, even though their price increases, for their marginal cost has increased at their old level of production, *OH*.

Thus, on the assumptions of non-inferiority and that the increase in production of tradeables is not positively related to non-tradeable production (i.e., that it is not *inversely* related to the input of other factors of production), one can expect the price of non-tradeables to rise and production of tradeables to increase.[2] There is no reason, however, to presume one way or the other regarding the change of output of non-tradeables. While increased income encourages demand for them, their increased price and marginal cost discourage it.

IV Tradeables, Non-Tradeables, Labour and Rents

We now consider some implications of mineral discoveries in a model in which factors of production are explicit. It is assumed that there are three goods—exportables, importables and non-tradeables—and at least three factors of production. However, only one factor of production, labour, is mobile between the three industries. It is assumed that non-tradeables are produced by labour alone, while exportables and importables require labour and other factors which, in the period considered, are assumed immobile. We assume decreasing returns to increasing

[2] This analysis is relevant to the concern some writers have expressed for the neglect of the role of demand in the rise in the relative price of non-tradeables in the 'Scandinavian' model (e.g. Kierzkowski 1974; Flanders 1975). The required demand condition is much weaker than that investigated by Kierzkowski—homothetic community preferences.

applications of labour to the specific factors while there are constant returns to labour in non-tradeables.

The base *OA* of Figure 4 shows the amount of labour available. Use of labour in the production of the exportable goods and in tradeable goods as a whole is measured from the left hand side; use in non-tradeables is measured from the right hand side. The left-hand vertical axis measures the marginal product of labour in exportables or tradeables (remembering the assumption of constant terms of trade), while the right-hand vertical axis measures the marginal product of labour in non-tradeables. Assuming tradeables to be the numeraire, the marginal product in the non-tradeables industry is measured in tradeables. The curve *LM* shows the marginal product of labour in exportables, *TW* shows it in non-tradeables, assuming the equilibrium tradeables/non-tradeables price ratio. We now introduce the marginal product of labour in the production of importables: this is drawn in relation to the movable axis *BZ* and is shown by the line *NP*. We assume an initial equilibrium with the three values of the marginal products of labour (given the equilibrium price ratio) equal and equal to the wage rate. *OB* of labour is in tradeables, of which *OC* is in exportables and *CB* in importables, while *AB* of labour is used in non-tradeables.

Assume now that there are mineral discoveries so that the specific factor in exportables is supplemented and that the marginal product of labour in exportables rises by the proportion *k* at every level of labour input, causing *LM* to shift to *L'M'*. (This is consistent with Figure 3(b) above.) It is apparent that the direction of response of several variables is determined by the extent to which the price of non-tradeables rises—this is reflected by the extent to which the 'marginal product of labour in non-tradeables' curve, *TW*, rises.

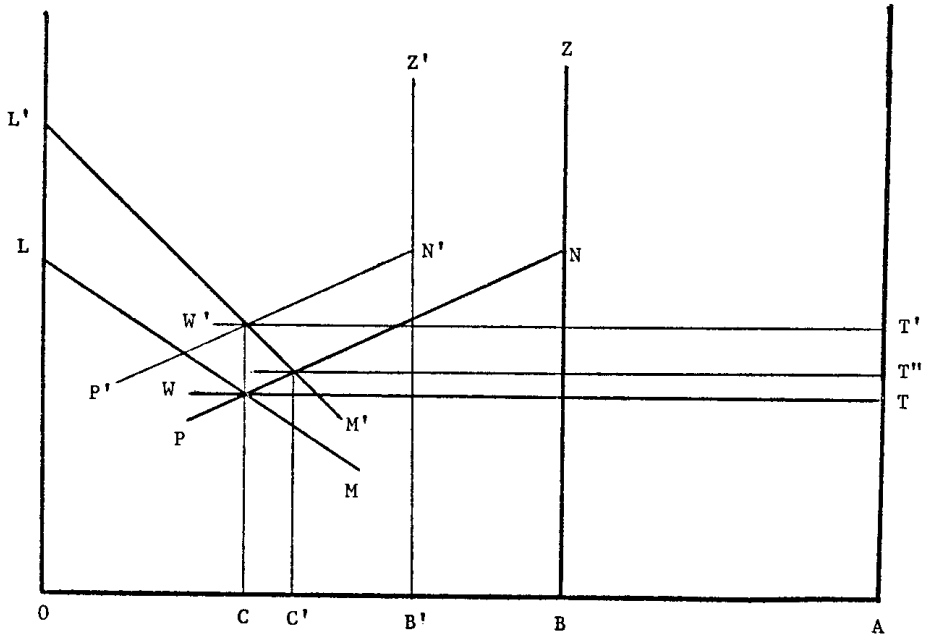

FIGURE 4

Consider first a rise in the price of non-tradeables by the proportion 'k'. The marginal product of labour in non-tradeables (measured in tradeables) would increase in the proportion k from TW to $T'W'$, and the marginal product of labour in exportables and importables would also rise in proportion k. This would be achieved at an unchanged usage of labour in exportables, so that production increases by the proportion k, but with reduced production of importables. Use of labour in importables would decrease from CB to CB', while the use of labour in non-tradeables would increase to AB'. In this case rents to the factors specific to exportables would rise in the proportion k, as do wages, while rents in importables would fall.

Consider now the implications of a rise in price of non-tradeables just to an extent to keep production of non-tradeables, and its use of labour (AB), unchanged—we define this proportion as r (which equals TT''/AT). The use of labour in exportables would increase to OC' while that in importables would decrease by CC'. In this case rents to factors specific to exportables would increase by *more* than the proportion k. (On the original labour input of OC the value of exportable production rises by the proportion k while wages increase by the lesser proportion r; additional rents are also earned on the extra labour input CC'.) Rents to the factor specific to importables would decline less than in the previous case.

Suppose now that prices of non-tradeables increase by less than the proportion r. Now non-tradeables production will decline despite the rise in price of non-tradeables, and the importables' 'axis', BZ, will move to the right. (This is not shown in the diagram.) Rents to exportables will increase even more than in the previous case while the decline in rents in importables will be further eased. However as long as the price of non-tradeables, together with the wages of labour, rises at all, rents in importables will be squeezed in this simple model. As these rents decline in terms of tradeables, they must decline in terms of all commodities.

The simple model brings out the high sensitivity of rents in the exportable and import-competing industries, and suggests why interests in these industries appear to react rather strongly to changing industrial structures. Mineral discoveries have a 'magnified' effect on rents in the mineral industry (*cf.* Jones 1971, p. 9), rising in greater proportion than does output per man, unless the price of non-tradeables rises in a proportion at least as great as the productivity of labour in minerals.

V Summary

Allowing for general equilibrium repercussions, but still accepting his general assumptions, some of Gregory's conclusions regarding the impact of new mineral discoveries require modification or extension:

(a) Although production of goods other than minerals can be expected to decline, the production of some goods in this category may rise;

(b) A social gain is still possible even if outputs of other goods do not change;

(c) While the price of non-tradeable goods can be expected to rise, production of non-tradeables may increase or decrease.

We also show the magnified effect of mineral discoveries on the rents

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