THE UNIVERSITY OF YORK

EEEM

Department of Environmental Economics and Environmental Management

Discussion Papers in Environmental Economics and Environmental Management

Number 9402 January 1994

THE EFFECT OF THE MINING SECTOR ON DEVELOPING ECONOMIES

by

David I. Stern

Heslington, York, YO1 5DD
Telephone: 44 (0)904 432 999
Telefax: 44 (0)904 432 998

The Effect of the Mining Sector on Developing Economies

David I. Stern

University of York

January 1994

Abstract

There has been much debate about the contribution of the mining sector to economic development in developing countries, though multi-country empirical studies have been very limited. Vector-autoregression models are used to determine the contribution of the mining sector to economic development in nineteen developing countries. Impulse response functions estimate the multiplier of mining output on non-mining GDP, net foreign factor payments, imports, manufactured capital, and human capital. The results indicate that in the majority of countries, the mining sector contributes little or nothing to GNP and factor accumulation. In a few countries, however, mining does contribute to economic development.

JEL Classification : O13 Economic Development : Agriculture, Natural Resources, Other Primary Products

Key Words : Mining, Economic Development, Econometric Analysis, International Comparison.

Department of Environmental Economics and Environmental Management, University of York, Heslington, York YO1 5DD, ENGLAND. Tel : 44 (904) 434061 / 656938 Fax : 44 (904) 432998, E-Mail : dis5@tower.york.ac.uk

The Effect of the Mining Sector on Developing Economies *

1. Introduction

There has been much debate over the relationship between the mining sector in the Developing World and economic development and growth, often as a subset of the more general debate concerning the trade relations of developed and developing countries and the implications of these for development [eg. see Labys (1980a) and Soete (1980)]. This has been particularly the case when mining developments have been owned by multinational corporations (MNCs). Proponents of the 'dependency school' and other structuralist economists have harshly criticized such operations characterizing them as either detrimental or useless to the development of LDC economies. In many developing countries governments followed these prescriptions and nationalized or severely taxed the mining sector. The results were often far from impressive. Per capita income has declined over many years in many countries with non-fuel mineral sectors. On the other hand a few countries like Botswana and Cameroon have achieved considerable economic development hand in hand with the development of their mining sectors. These developments indicate that the problem is neither with MNCs in particular nor with the mining sector in general. Recently the attitude to MNCs has changed in almost all the countries where they were previously so despised. This is partly in response to the poor results obtained from alternative routes to development, but also in realization that

* I would like to thank Judith Rees, and Beverly Mullings for initiating my interest in issues relating to the mining industry in developing countries. Jere Behrmann, Cutler Cleveland, Robert Kaufmann, Paul Parker, Lopamudra Patnaik, Matthias Ruth, Max Steuer, and anonymous referees provided useful comments. I would also like to thank the Economic and Social Research Council, the Institute for the Study of World Politics, and the John D. and Catherine T. MacArthur foundation for funding.

MNCs are "merely a part of a much wider force that has eroded sovereignty while integrating the world economy" [Emmott (1993)] ie. the internationalization of capital markets. There is no real choice but to participate in the global market [Schmookler (1993)].

Opinion among mainstream economists has been more mixed. The development of a mining sector is seen as being as beneficial as the development of any other sector in the economy, and perhaps more so, as rents from mining can be used to increase savings or take the place of foreign aid in funding necessary imports [Daniel (1992)]. Some mainstream analysts [eg. Fozzard (1990), Nankani (1979)] have attributed the failures of development in mining economies to failures of government policy. Other neoclassical economists have shown that rapid resource booms may have detrimental effects on the rest of the economy known as the 'Dutch disease', and there is also evidence that the mining sector has a lower level of linkages with the rest of the economy than do other sectors [Yotopoulos and Nugent (1973), Gelb et al. (1988)].

Despite continued interest in the relationship between the mining sector and economic growth and development [eg. Auty (1991), Tilton (1992)], it seems that no study similar to the series of econometric studies investigating the relation of trade and growth in cross-sections or groups of countries [see Edwards (1993) for a survey], has been conducted in the case of the mining sector, to go beyond the "verbal correlations" [Nankani, (1979, p85)] of dependency theorists and neoclassical policy analysts. There are, though, some single country studies [eg. Lira (1980), Adams and Behrman (1981), Lasaga (1981), Nziramasanga and Obidegwu (1981)] and also some econometric evidence concerning the Dutch disease [Gelb (1986), Taylor *et al.* (1986), Warr (1986)]. This paper surveys some of the arguments against the mining sector from both the dependency theory and the neoclassical viewpoints and goes on to discuss the paucity of econometric studies of the subject. Then an econometric model is developed to test some of the relevant hypotheses. This model consists of a series of vector autoregressions, one for each of nineteen countries. The remainder of the paper is occupied by the presentation and discussion of the results.

2. What are the Issues ?

Both mainstream and radical economists have made a number of arguments against the mining sector as a source of economic growth in developing countries. The neoclassical economists' arguments tend to be highly specific to the mining sector. Dependency theorists and some structuralist economists tend to view the problems associated with mineral based development to be severe cases of general problems of development. However, there are substantial differences between individual schools of thought [Palma (1978)] and it is impossible to present a single coherent anti-mining sector thesis based on dependency theory. However, there is an underlying theme linking the various critiques. Many of the criticisms of the mining sector in developing countries are equally relevant to all export industries in developing countries. As there is a large literature in this area [see Salvatore (1983)] I concentrate on only those phenomena associated with mining in particular.

Capital intensive technology has been criticized as a typical phenomena of mineral exploitation. Often employment impact is minimal and skilled work may be restricted to expatriates [Tanzer (1980)]. Projects operated by MNCs may have higher capital intensity than those run by local corporations, as multinationals may experience lower capital costs than those experienced by local entrepreneurs. In a study that was controlled for industry mix and other variables, Morley and Smith (1977) found foreign firms in Brazil to be more capital intensive than local enterprises in approximately half of the industries that they analyzed. Reuber *et al.* (1973) found that the majority of MNCs responding to their survey paid the prevailing wage in the developing country in which they operated. Further, they found that managerial and engineering positions had only a bare majority of nationals when the average project began, but the proportion had risen to 70% by the time of the survey. However, this survey did show that the skilled proportion of the workforce is much lower for export-oriented subsidiaries, such as mining companies, than for those serving domestic markets.

Mining has also been criticized for a particularly low level of production and consumption linkages with the rest of the economy. Capital goods and inputs are mainly purchased abroad and output is sold there [Adler (1961), Kindleberger (1961), Baldwin (1966), Fry and Harvey (1974), Reynolds (1965), Mikesell (1974), Killick (1974)]. Gelb et al. (1988) point out that as mining is a rent generating sector, or in other words one of the major inputs to mining output is the natural resource base, the ratio of purchased inputs to output will be necessarily lower than for manufacturing industries. The most important potential linkages, especially in the least developed economies, are fiscal linkages [Nankani (1979)]. Because mineral resources are exhaustible, mineral dependent economies need to extract rents and invest these in transforming the economy before the deposits run out [Solow (1974), Hartwick (1977)]. However, there can be a problem of 'government failure'. Bomsel (1992) shows that some governments have used mining rents not just in wasteful or unproductive ways but in ways that damaged other sectors of the economy. For example Zambia used mining revenues to finance food imports that undercut its own agricultural sector. Daniel (1992) points out that if governments try to use mining rents to fund domestic investments they may quite quickly run into capacity constraints in terms of the economy's ability to produce the necessary capital goods or to utilize them effectively. He recommends that governments invest abroad that part of the rent that cannot usefully be used domestically as in the example of Kuwait's investment funds.

Transport is a linkage that is likely to be important. Because of the bulk and spatially concentrated nature of minerals infrastructure may also be distorted to serve the needs of mining - though again it is difficult to see why the ownership of companies should be of particular significance here. Siedman for example criticizes the enclave nature of the mining sector in Zambia in 1964; 'Almost no schools, hospitals or even tarmac roads were constructed away from the narrow strip along the line of rail' [in Cobbe (1979, p230)]. Development might not be optimal, but "there would have been virtually no development in Zambia without the copper mines" [Fry and Harvey (1974, p194)]. A company serving foreign strategic interests may divert transport routes to access an economically sub-optimal market [Rees (1985)]. However, the high cost of land transport infrastructure and operation compared to low sea transportation costs means that in almost all cases this would have no practical implications. The shortest land route to the nearest port tends to be constructed irrespective of the final market destination of the commodity.

Repatriation of profits by MNCs can limit the benefits to be gained by developing countries from the mining sector [eg. see Girvan (1974) and Rees (1985)]. These 'profits' include both a return to capital and a resource rent. Regarding the first component, a similar argument would apply to an LDC that borrowed abroad to finance mining operations in local private or state ownership and was obligated to make substantial interest payments. Multinational ownership is not a necessary condition for capital transfers to developed nations to occur as a result of investment in developing countries and obviously not only investments in the mining sector result in such transfers, this is an argument relevant to all industries. Some observers have argued instead that differences in private risk depending on the location of the deposits might lead multinationals and banks to expect higher rates of return on projects in the Developing World [Rees (1985)], leading them to 'underinvest' relative to their activities in developed nations. This can hardly be an argument against the involvement of MNCs, as in their absence the level of investment would be even lower, and this also contradicts the argument concerning risk noted above. This risk has often been higher for mineral developments than for non-mineral developments because of the presence of the second, rent, component. The argument is that MNCs will repatriate mineral rents in as far as these are not taxed by the host government, whereas if the project was locally developed the rents would remain within the country. This is seen as more equitable as the mineral stock is the factor of production offered by the host country, and consequently the prevalence of arguments in favor of the nationalization of the mining sector. The situation is complicated by the fact that market prices may not include a rent component at all. El-Serafy (1989) argues that this was the case in the petroleum industry in developing countries before the oil price shocks of the 1970s. When mining is capital and resource intensive, with a low level of linkages, and the surplus does not include a taxable rent component, one would expect the development benefits to be gained to be minimal.

Benefits may be further curtailed when a mining company has monopsony power that may allow it to set the export price of minerals below competitive rates, thus reducing the royalties accruing to host governments. When transfer pricing occurs, ie. in sales of commodities between branches of the same corporation, any price whatsoever can be assigned [Labys (1980b)]. Available solutions are either royalty taxes as a percentage of world prices (not always possible if a monopolist or a cartel dominates the world market) or per unit output taxes [Brower (1987)]. So the existence of adverse effects from discriminatory pricing is mainly due to a lack of government action. Governments may not, however, always be in a position to act when there is an asymmetry of power of this type. Criticism is also levelled at the volatility of mineral prices [Rees (1985), Nziramasanga and Obidegwu (1981)]. These may lead to violent fluctuations in the value of mining sector output and profits. This can be especially detrimental if a large proportion of government revenue is derived from the mining sector. In this case government spending becomes difficult to plan and large potentially inflationary deficits may occur.

The ownership of mining developments may be of importance when there is an asymmetry in the bargaining powers of the mining companies and governments involved. In general though development problems related to the mining industry are likely to be the result of the nature of the industry itself, in terms of capital intensity, linkages, its nature as a rent-generating industry etc., or alternatively of government failure.

In the last couple of decades mainstream economists have recognized that mining developments have not always been very successful in promoting development. Nankani (1979) presents data that indicates that relative to the non-mineral economies, non-fuel mineral economies have : lower saving, greater technological and wage dualism, higher unemployment, lower school enrolment, higher inflation, slower agricultural sector growth, greater export earnings instability, and greater export concentration. One response to this has been the Dutch disease literature. The fact that natural resources are a sectorally specific factor is the reason for the existence of the Dutch disease phenomenon in an economy with a booming minerals sector.

Corden and Neary (1982) discriminate between the spending effects of increased income in the minerals sector, which typically causes a real appreciation and the substitution of imported goods for domestic tradables, and the resource movement effect, which is the movement of factors of production to the minerals sector as a result of the rise in the marginal products of mobile factors employed there. This phenomenon means that when national income derived from mining increases it may be offset by a decline in income elsewhere in the economy. The majority of empirical studies have corroborated this model [eg. Gelb (1986), Forsyth (1986), Warr (1986)] or variations of it [Benjamin *et al.* (1989), Fardmanesh (1991)]. In all these cases the mineral considered has been oil, though this need not be so [Banks (1992)]. Bomsel (1992) and Daniel (1992) suggest that government policy can counteract the negative effects of the Dutch Disease in terms of wage and exchange rate policies.

The other approach has been policy analysis emphasizing government failure. Exports lead to development only if the social milieu and policy environment are supportive. "The success of the mineral economies will depend significantly on the quality and mobility of their internal factors of production, and on the policy environment they establish for economic decision-making. Together, these two sets of factors will determine their capacity to transform as their mineral rents wither away or as demand for their mineral decreases" [Nankani (1979, 6)]. Nankani concludes that the economies with the greatest mineral reserves appear to be acting as if their minerals were depletable whereas the economies where the minerals are actually in greatest danger of being depleted appear to be acting as if the minerals were non-depletable.

Government failure is emphasized by Fozzard (1990), who notes that with two or three important exceptions, sub-Saharan Africa's share of mineral production has been declining compared to that of other regions. Whereas in some cases ore reserve depletion has been a factor, the most important underlying cause has been the absence of an enabling environment to attract high-risk exploration investment and to support private sector mining development, as many countries clearly have great potential for future mineral 'discoveries'. However, the rates of exploration relative to output have been very low compared to other regions of the world.

There has also been insufficient re-investment by the region's state dominated mining enterprises. Overall, growth is unlikely to occur unless an enabling environment is created to secure and maintain the appropriate levels of investment. The World Bank initiated an African Mining Policy Study with the objective of recognizing and then introducing required adjustment processes into the region's mining industry [Fozzard (1990)]. In particular the policy suggests that governments should be more aggressive in promoting mineral exploration and investment and in setting up institutions for the compilation and dissemination of geological information.

3. Quantitative Studies

Despite the extensive literature on the subject it seems that there has been no quantitative multi-country study on the effects of the mining sector on economic development and growth. Research has been mainly limited to non-quantitative or non-econometric case studies [O'Faircheallaigh (1984)], and has tended to focus on foreign investment alone [eg. Girvan (1972) and Mikesell (1971, 1975)]. Case studies such as those by Mikesell (1974) on copper in Zaire, Fry and Harvey (1974) on copper in Zambia, and Killick (1974) on mining in Sierra Leone are quantitative but non-econometric. Their technique is to list the contribution of the mining sector in a particular year to taxation, employment, purchases of the outputs of particular industries, and other quantities. This type of analysis omits dynamic effects. Similarly one of the few multi-country surveys of the impact of mining on LDC economies [Gluschke, Iwase, and Zorn (1980)] lists the shares of the minerals sector in GNP, exports, employment etc. in a range of countries and describes other impacts, but backward and forward linkages and other dynamic effects are ignored.

A small group of studies produced by researchers at the University of Pennsylvania [Adams and Behrman (1981)] have applied econometric techniques to the linkages between the primary commodity sectors and the general economy in single developing countries. Lasaga (1981) estimates the impact and dynamic multipliers of the copper sector on GDP. The impact multiplier of a 10% increase in copper production was 2.8, while the multiplier of investment in the copper sector was 3.6. A sustained 10% increase in production by the large scale copper mines lead after five years to a 6.48% increase in national income. As large scale mining accounted for 4.8% of GDP over this period, this represents an effective dynamic multiplier of 13.5 ! Similarly investment in the copper sector was found to be more effective than in the non-copper sector. Lira (1980), however, found that an increase in copper prices led to an increase in Chile's GNP in the first four years and then a decrease in subsequent years from 1960 to 1968, under the assumption that the government maintained its expenditures at pre-shock levels. If the government increased its expenditures then GNP rose throughout the period. Nziramasanga and Obidegwu (1981) compare their base case historical simulation for 1968-1976 with simulations in which copper prices and copper output are changed by 10% on a sustained basis [1]. A 10% increase in copper prices yields a 0.55% increase in real GDP in the first year rising to a 2.93% increase in GDP after nine years. A 10% reduction in copper prices leads to -0.59% and -3.52% changes in real GDP after one and nine years respectively. A sustained 10% increase in copper output causes a 1.96% increase in real GDP after one year, a 2.72% increase after two years and fluctuating values after that, for an average of 2.02%. Interestingly, however, the effect on non-copper real GDP averages -0.13% over the nine year period. A 10% decrease in output led to an average 0.18% increase in non-copper GDP.

Yotopoulos and Nugent (1973) evaluated the strength of the linkages between eighteen industries in six developed and five developing countries (Chile, Greece, Korea, Mexico and Spain) using input-output tables to calculate linkage indices. In developing countries these indices ranged from 2.393 in leather to 1.413 in services. The linkage index of mining was seventeenth at 1.474.

Gelb (1986) traces the use of oil 'windfalls' in the 1970's and 1980's in six OPEC countries. The study shows that these were mainly spent on inefficient public investments, and that a

---

[1] They also examine an increase in prices that lasts for one year only.

'Dutch disease' type effect occurred as the growth rate of non-mining GDP fell over the period while the oil sector expanded. This study is limited though to a single mineral only and to a limited set of countries [see also Warr (1986), Taylor *et al* (1986), Benjamin *et al.* (1989)].

Overall the econometric evidence that there is regarding the effect of the mining sector on developing economies is rather mixed.

4. Development of an Empirical Model

In the absence of a relevant literature, multi-country empirical studies of the impact of trade on economic development can contribute to the development of an empirical approach to the question of the effect of the minerals sector on economic development and growth. Rather than examine the impact of a general exports producing sector on growth I am interested in examining the effect of a minerals sector, that may produce largely for export, on growth. Three main approaches have been taken in the multi-country empirical analysis of the effects of exports on growth : Simple correlations, single equation models and multi-equation econometric models.

There are problems with all the three main types of model found in the exports and growth literature in estimating the size and sign of the multiplier between two sectors of the economy. The bivariate correlation models [eg. Michaely (1977)] attribute all the systematic change in the dependent variable to the change in the independent variable, therefore probably exaggerating the strength of the relationship, as there may be other variables that act on both the dependent and independent variable resulting in a spurious correlation. Also, the direction of causality is not defined and the choice of dependent and independent variable is arbitrary.

Single equation regression models [eg. Feder (1983)] go to the opposite extreme, arbitrarily selecting a single dependent variable. There is a tendency to underestimate the size of the multiplier in these models. All the conditioning variables are treated as exogenous variables.

For example if the capital stock is one of the conditioning variables in an equation explaining non-mining income, all the effect of a change in the capital stock on income will be attributed to an exogenous movement in the capital stock. If the change in the capital stock is partly due to a change in mining income, this channel of influence of the mining sector on the non-mining sector will be ignored.

Finally, simultaneous equation models [eg. Salvatore (1983)] overcome some of these problems as long as they allow sufficiently for lagged effects [2] and do not make too many restrictions on which variables enter which equation [3]. Both mining and non-mining income should be endogenous variables as they are produced using labor, capital, natural resources etc. This raises problems with the traditional method of estimating multipliers from exogenous to endogenous variables. Salvatore (1983) makes dX/dt and Y exogenous (X is exports, Y is GNP) and X and dY/dt endogenous. This seems rather arbitrary.

Edwards (1993) surveys the econometric studies of trade and growth. He is not impressed by the results of the cross-country regression approach and argues that most of the results purporting to show that exports specifically have increased the rate of economic growth in developing countries are "unconvincing results whose fragility has been exposed by subsequent work" (1389) [see also Stern (1994)]. He points to two directions for further research : investigators should approach the issue from the new growth theory discussed below, while employing more sophisticated econometrics than has been the case; and that microeconomic analysis could shed new light on the issue. I adopt the former of these approaches.

This assertion has been supported by Levine and Renelt (1992), who carried out a sensitivity analysis of the regression coefficients of particular variables that previous studies had

---

[2] which is not the case in Salvatore's (1983) model.

[3] Sims' (1980) critique.

suggested were correlated with either growth per capita or the investment / output ratio in cross-country regressions using period averages. They estimated regressions which always included a particular subset of variables and a changing group of other conditioning variables. They found that few relationships are robust to changes in the conditioning set. Those that are, are investment, initial income per capita, and secondary school enrolment, in regressions of the growth in per capita income; and exports and measures of trade openness, in regressions of I/Y. Particularly noteworthy is that the trade variables do not have a robust relationship with income growth. Trade appears to have positive effects through accumulation of capital. Also they found that substituting imports for exports in the investment equation did not have much of an effect on the estimated coefficients or levels of significance.

Hence I have chosen to adopt the vector autoregression (VAR) approach to modeling the interactions between the mining sector and the rest of the economy. The VAR approach treats all the variables as endogenous, though exogenous variables can also be added. More importantly it allows the estimation of dynamic multipliers between the endogenous variables by means of the impulse response functions. Its main problem is that with limited numbers of observations degrees of freedom or the number of lags that can be used is limited. The approach does not allow the pooling of time series and cross-section data which limits the number of observations in each model. An individual model has to be estimated for each country unless the data are aggregated for the "World Economy". I have chosen not to aggregate the data, as the dynamics are not necessarily in phase in each economy, most of which are fairly closed with the exception of their mineral exports.

I have tried to take into account some recent developments in growth theory in selecting variables for this model. Lucas (1988) emphasized the central role of the formation of human capital in economic growth both through its function in the improvement of labor inputs and through an additional externality effect. He points out that exports industries can help in the formation of human capital through learning by doing. Romer (1986) emphasized the possibilities of increasing returns to scale emerging from the effects of the formation of knowledge or human capital. This is as knowledge behaves as a public good and knowledge created by one agent in the economy has an external effect on the production activities of other agents.

Both Barro (1989) and Otani and Villanueva (1990) have explored the empirical implications of these theories and in particular the effects of human capital endowments and formation on rates of economic growth. Barro (1989) examines what factors could account for variations between GDP growth rates among 98 developing and developed countries. Neoclassical growth theory suggests that there should be a negative correlation between GDP per capita at the beginning of the period and the GDP growth rate throughout that period, but there is no correlation in the sample. But if human capital at the beginning of the period is held constant then the hypothesis is shown to hold true. Further regressions show that countries with higher initial levels of human capital also have higher investment rates and lower fertility rates. The main measure of human capital used is primary and secondary school enrolment. Barro argues that this lends some support to the new growth economics. Otani and Villanueva's (1990) paper provides further empirical evidence to support the inclusion of human capital as an independent variable in any model purporting to explain growth rates.

The VAR is used to linearly approximate a dynamic transformation frontier :

$$g(N_t, M_t, F_t, K_t, L_t, H_t, I_t) = 0 \qquad (1)$$

where there are three outputs : M, mining GDP; N, non-mining GDP; and F, net foreign factor payments; and four inputs : K, capital; L, labor; H, quality of human capital; and I, imports, though use of the VAR methodology means that no variable is strictly an input or an output. Due to limited degrees of freedom only one annual lag was used in each VAR model. The variables were used in the simple levels form. This was due to consideration of the implications of different functional forms on the meaning of the estimated multipliers. In order to obtain time-invariant multipliers values rather than logarithms were chosen. This form also simplifies treatment of net-foreign factor payments which can be either positive or negative. The levels form implies that the multiplier measures the impact of a temporary change in mining income, the differences form implies that the multiplier measures the impact of a permanent increase in mining income. The proxy used for the quality of human capital is the sum of primary, secondary and tertiary enrolment rates. This is similar to Barro (1989) but with the addition of the tertiary level. Data sources are in Appendix A. This formulation is inaccurate as current school enrolment rates reflect improvements in the workforce in the future. However, economic growth contributes to human capital growth through current education. Due to both this and the fact that school education does not include all the improvement in human capital, current school enrolment seems a reasonable proxy. Tertiary education is added because in some countries such as Chile, secondary enrolments were fairly high at the beginning of the period. Labor is estimated as the population multiplied by the participation rate. The VAR model consists of the following equation system :

$$y_t \quad = \quad B\, y_{t-1} + e_t \qquad (2)$$

where

$$y_t \quad = \quad [\, 1, N_t, M_t, F_t, K_t, L_t, H_t, I_t]',$$

B is a matrix of regression coefficients, and e is a random error term. Output and imports are measured in local currency deflated by the GDP deflator and multiplied by the real international dollar exchange rate in 1980 derived using the Penn World Table. These units were chosen to facilitate comparisons of the multipliers of mining GDP on the labor force and human capital which are not in monetary units. As the model is linear this does not affect the estimates of the other multipliers. Deflating mining income by the GDP deflator rather than by the mining sector deflator means that both a change in the price of minerals or a change in the volume of mining output can have an effect on the other variables. A separate VAR model is estimated for each country. Nineteen countries were selected as described in Appendix A. This appendix also describes the sources of data for each country. If possible the time period covers 1963-1988, but data was not always available for the entire period. Details of the construction of the capital input are described in Appendix B.

The multipliers are estimated using the impulse response functions of the VAR [see Sargent (1979) and Sims (1980)]. The impulse response functions are based on the moving average representation of the vector time series [see Doan (1989), Sargent (1979)] :

$$y(t) = \sum_{s=0}^{\infty} G(s)\, u(t-s) + X(t)\beta \qquad (3)$$

where the G are matrices of coefficients, $X(t)\beta$ is the deterministic part of the VAR, and u is an n-variate white noise process. If $t \neq s$, u(t) and u(s) are uncorrelated. If G(0) is normalized to be the identity matrix, each component of u(t) is the error that results from the one-step forecast of the corresponding component of y(t). These are non-orthogonal innovations in the components of y. It is generally recommended to use instead a moving average representation with orthogonalized innovations [Doan (1989)]. For any non-singular matrix A, G(s) can be replaced by G(s)A and u by $A^{-1}u$. If the matrix A is chosen such that :

$$A^{-1} \Sigma A'^{-1} = I \qquad (4)$$

then the new innovations $v(t) = u(t) A^{-1}$ satisfy $E(v(t)\, v(t)') = I$. These orthogonalized innovations have the convenient property that they are uncorrelated both across time and across equations. Such a matrix A can be any solution of $AA' = \Sigma$. The standard choice which I use is the Choleski decomposition so that A is a lower triangular matrix. There is a different factorization for each ordering of the variables that compose y and this will affect the resulting estimates of the impulse response functions. Each variable can only be affected contemporaneously by variables higher up the ordering. As only the impulse response functions to a shock to mining GDP are to be considered it is logical to place mining GDP as the first variable in the ordering. The remainder of the ordering is unimportant. For some countries the initial unrestricted VARs exhibited severe oscillations in the time paths of the impulse response functions. To help reduce these oscillations Bayesian VARs were used. I used the RATS manual's standard recommended prior distribution for the coefficients [Doan (1989)]. The mean of the multipliers in the sample is examined to determine what the effect of the mining sector is on current income and on investment and the consequent implications for dependency and sustainability. The estimates of the multipliers in the individual countries are also compared to determine whether they are similar or whether countries with particular characteristics share similar size multipliers.

5. Exploratory Analysis

Figures 1 through 5 present some background information on the economic performance of the countries in the sample. Figure 1 compares the mean annual growth of mining and the growth rate of non-mining GDP. The units for the mining sector are percentage points of GDP which are calculated as the multiple of the growth rate and the sector's share in GDP. There is clearly a positive relationship between the two variables and the correlation coefficient is 0.44. The four countries with the greatest relative growth in their mining sectors are labelled. All four countries have mining sectors that effectively commenced production during the sample period and experienced very rapid rates of growth in their mining sectors. Oman and Botswana appear to have been more successful in generating growth in the remainder of the economy. The remainder of the observations show a steep relationship between the growth of non-mining and mining GDP. This is primarily because the non-mining sector is much bigger than the mining sector in all these countries. The regression line relating the growth rates of mining and non-mining GDP has a slope of less than one.

Figure 2 relates the growth rate of net foreign factor payments to the growth of mining GDP. The correlation between the two variables is 0.05. This is the expected sign but the relationship is very weak. Botswana again shows up as an outlier to the right and Sierra Leone is the outlier to the bottom with a steep decline in net foreign factor payments. Figure 3 relates mining GDP growth to the growth rate of imports. The correlation is 0.45 which has the expected sign. Botswana, Oman, Cameroon, and Papua New Guinea again lie to the right of the apparent main trend. Again Cameroon and Papua New Guinea experienced lower import growth rates than Botswana and Oman. Figure 4 presents the relationship between the growth rate of the capital stock and the growth of the mining sector. The correlation of 0.85 is far stronger than the other correlations. In this case Cameroon has been more successful in generating capital accumulation than either Papua New Guinea, or Oman. Botswana remains the star performer. Finally Figure 5 presents the relationship between the growth rate of human capital (labor force multiplied by quality of human capital) and mining growth. Oman achieved an outstanding growth rate by starting from a base of almost zero schooling. The correlation between the two variables is 0.26 which has the expected sign.

6. Econometric Analysis

The model produces large quantities of statistics and data, and only the main points can be presented in a reasonable space. I do not present diagnostic statistics or coefficients from the individual VAR models as there are 133 equations, 931 Granger statistics, and 1064 coefficients. Instead various multipliers of mining GDP on the other endogenous variables are presented.

Table 1 presents multipliers of mining GDP on mining GDP itself. This induced change in mining output in later years should be taken into account in estimating the long-run effects of mining GDP on the other variables. The shock to mining output is one real international dollar of GDP. Therefore the first period multiplier is one. There are twenty six years of multipliers. The sample means of the multipliers for the second to fourteenth period were significantly different from zero at the 10% level in a two sided t-test. The long run multiplier refers to the multiplier for the twenty-sixth period. The sum of multipliers is the total induced increase in mining output including the first year.

Often a shock to mining output leads to increased mining output for a certain period and later a decrease in mining GDP relative to the base case. This makes sense, as for example, a price shock would lead to new investments in mining capacity in the short term and in the longer term reduced output due to faster depletion. This general pattern is made clear by the time path of the mean multiplier shown in Figure 6. Otherwise there is no apparent relationship between the sum of multipliers and the nature of the individual economies. The sum of induced mining output is significantly different from zero and its mean is 3.94.

Table 2 presents the multiplier of mining GDP on non-mining GDP. The adjusted sum of multipliers is the sum of multipliers over the twenty six year period divided by the induced change in mining GDP. The sample mean of the impact multiplier just fails the 10% significance test. None of the sample means of the other multipliers nor the sum of multipliers, are significant at the 10% level, though a few of the t-statistics are greater than one in absolute value. Figure 7 presents the time-path of the mean multiplier. The figure shows that there is a tendency for the impact multiplier to be negative and subsequent multipliers to increase, becoming positive from the sixth through the twenty-third periods after which they are negative and insignificantly different to zero. This pattern can be explained by the diversion of resources to the mining sector during a boom followed by the spread effects of spending in the rest of the economy in later periods which gradually dissipate over time. This suggests that the spending effect dominates any linkage effect and that overall the mining sector contributes little or nothing to GDP growth in the rest of the economy, failing to falsify the hypothesis of an enclave sector. However, in some countries the sum of multipliers do seem to be quite positive, though there are no statistics to back up this claim. The adjusted sum of multipliers is positive in : Cameroon, Malaysia, Oman, Togo, and Tunisia. This includes one of the larger and / or more developed economies which would presumably have greater possibilities for the development of linkages, but excludes Mexico and South Africa. Botswana, the star economic performer of the entire sample of countries, is missing from this group implying that the mining industry is not the engine of growth in that economy. Independent confirmation is available from Unemo (1994) who estimates a computable general equilibrium model for Botswana using 1985 data. She finds that a 5% fall in the price of diamonds leads to a 1.08% fall in GDP. However, the fall in mining GDP totalled 47.5 million Pula and the fall in total GDP totalled 26.0 million Pula. Therefore the multiplier of mining GDP on non-mining GDP was -0.453. This compares with my impact multiplier of -0.545 and second year multiplier of

-0.437. These are probably the relevant figures as the CGE does not reflect long-run growth effects.

Table 3 presents the multiplier of mining GDP on net foreign factor payments and Figure 8 presents the time path of the mean multiplier. The mean of the multiplier is positive for all periods. The mean of the impact multiplier is significantly different from zero at the 10% level as are the multipliers from the twelfth through the twenty-second period, and the adjusted sum of multipliers. All the t statistics are greater than one. We can reject the hypothesis that the growth of the mining sector does not increase net foreign factor payments. Overall a $1 increase in mining output results in a mean 35c net payment to foreign factors. Above $1 adjusted sums occur in Colombia and Togo, which seems unlikely. In some countries the sum of multipliers was negative, these were : Chile, Jamaica, Oman, Peru, Sierra Leone, and Zimbabwe. These seem rather a mixed bag of countries so it is difficult to come to any strong conclusions on the basis of this data.

Summing up the information in the first three multipliers, Table 4 presents the multiplier of mining GDP on total GNP, and Figure 9 the time path of the mean multiplier. The mean of the multiplier is positive for the first sixteen periods and thereafter negative. The first five multipliers are significantly different to zero. The mean multiplier is significantly different to one in every period. This means that the fall in non-mining GDP and the increase in net foreign factor payments outweighs the increase in mining output. These results cannot reject the hypothesis that growth of the mining sector contributes very little or nothing to overall economic welfare in the average mining economy. However, there are several economies where the adjusted sum of multipliers is greater than one indicating a positive contribution to growth. Again there are no statistics to test these individual multipliers. The adjusted sum of multipliers is greater than unity in : Cameroon, Colombia, Malaysia, Oman, and Tunisia.

Table 5 presents multipliers of mining GDP on imports and Figure 10 the time path of the mean of the multiplier. The mean multiplier is positive through the twenty-fourth period and negative thereafter. It is significantly different from zero between the fourth and eleventh periods. This implies that in most countries mining induces imports only with a long lag, which again suggests that the spending effect is important. The adjusted sum of multipliers is significantly different from zero, and overall for each $1 increase in mining output imports increase by 33c over the sample period. It is possible to reject the hypothesis that increases in mining GDP do not increase imports. However, the increase tends to occur with a long-lag rather than to be associated with the initial shock, and we cannot reject that in the long-run imports return to their previous level. The adjusted sum was greater than 0.5 in Bolivia, Chile, Colombia, Jamaica, Liberia, Sierra Leone, Togo, Tunisia, and Zimbabwe. It is difficult to say whether this was a good or bad phenomenon as we do not know the composition of these imports, especially as there is a weak negative correlation between the sum of induced imports and the sum of induced non-mining GDP ($r = -0.096$). The sign of the relationship suggests that imports do crowd out domestic production but the relationship is weak. In many countries a decline in imports is associated with the increase in mining GDP, which is more difficult to explain. Some of these countries also experienced a decrease in total GNP, which might be an explanation. Also in Mexico increased oil output over 1963-1988 would have reduced imports of oil. Malaysia however has a very large adjusted sum of GNP multipliers. The signs of the time path of both multipliers do, however, coincide.

Table 6 presents multipliers of mining GDP on the capital stock, and Figure 11 the time-path of the mean multiplier. As this is a stock variable the sum of multipliers is meaningless. The mean impact multiplier is negative but not significantly different from zero. Only from the third period is the multiplier positive but insignificant. None of the multipliers is significantly different from zero at the 10% level. Referring to the multiplier in the twenty-sixth year as the long-run multiplier, the adjusted long-run multiplier is negative but also not significantly different from zero. Therefore, we cannot reject the hypothesis that the mining sector does not contribute to the long-term accumulation of capital. Though it is likely that there is some induced capital accumulation with a lag of a number of years (some t statistics greater than one), it appears that this capital is then allowed to depreciate to at least a certain degree. It is unknown whether my depreciation assumptions (see Appendix B) affect this result. Those countries where the adjusted long-run multiplier is positive are : Cameroon, Jamaica, Mexico, Oman, Peru, Togo, Tunisia, Zambia, and Zimbabwe.

Table 7 presents multipliers of mining GDP on the labor force. Again as this is a stock variable the sum of multipliers is meaningless. The mean is insignificantly different from zero, negative for the first sixteen periods and thereafter positive. The first six t statistics are greater than one in absolute value. The mean adjusted long-run multiplier is negative. However, some countries experienced gains in the labor force : Jamaica ($408000 of increased mining GDP generates one extra worker), Liberia ($84000 per worker), Oman ($1 million per worker), Peru ($457000 per worker), Togo ($61000 per worker), Tunisia ($131000 per worker), and Zimbabwe ($263000 per worker). Clearly mineral based development does not generate a lot of jobs !

Finally Table 8 presents multipliers of mining GDP on the quality of human capital and Figure 13 the time path of the mean multiplier. None of the multipliers is significantly different from zero. We can, therefore, accept the null hypothesis that growth of the mining sector does not contribute to the improvement of the quality of human capital. From the seventeenth period on the t-statistics are greater than one in absolute value so that it is likely that there is in fact some negative effect and that the long-run multiplier is negative. Positive adjusted long-run multipliers occur in : Cameroon ($32 billion required to raise enrolment in one of the three levels of education by 1% !), Jamaica ($18 billion), Mexico ($43 billion), Oman ($2.4 billion), Peru ($31 billion), Tunisia ($4 billion), and Zimbabwe ($1.1 billion). These figures represent around 25 years mining output in Cameroon (at the sample average level of mining GDP), 33 years in Jamaica, 3 years in Mexico, 8 months in Oman, 8 years in Peru, 3 years in Tunisia, and 2 years in Zimbabwe. So that clearly in only four countries would mining-based development be an effective strategy to increase the quality of human capital.

Is there a relationship between the factor accumulation multipliers and the GNP multiplier ? In other words is the model consistent with growth theory ? The correlation between the capital and GNP long-run multipliers is 0.1184. However, the correlation between the capital multiplier and the sum of the mining and non-mining multipliers (GDP multiplier) is 0.7957, though the correlation between the human capital multiplier and the GDP multiplier is -0.2002. Capital accumulation explains long-run GDP growth, though there appears to be no relation between human capital accumulation and long-run GDP growth. The large role played by net foreign factor payments in determining GNP in these developing countries means that just looking at the accumulation of factors in the domestic economy does not help very much in explaining GNP.

7. Conclusions

This paper has gone some way towards an empirical analysis of the relationship between the mining sector and economic growth and development in a group of developing countries. The results show that a more detailed analysis of the interactions between the mining sector and other macroeconomic variables can reveal relationships not shown by simple correlations or regressions. The most important example is Botswana where both the mining and non-mining sectors grew extremely rapidly. The econometric analysis presented in this paper, shows that the mining sector may have been a hindrance to possibly even more rapid growth in the rest of the Botswanan economy. Certainly it does not seem to have been the engine of growth one might have assumed.

Clearly it is not possible to reject in general the hypothesis that the mining sector generates few if any benefits for the host economies. However, there are a number of economies in the sample where benefits do appear to be accruing to the host economy from mining activities. In Cameroon, Colombia, Malaysia, Oman, and Tunisia, the cumulative increase in GNP over twenty-six years for a $1 increase in mining GDP was greater than $1 indicating that mining contributed to income beyond the immediate mineral revenues. These countries are all oil producers, though only Oman is exclusively an oil producer. Also, they are all middle income countries (MDCs). In a number of other countries the net contribution was less than the increase in mining GDP, these countries did benefit from mining if only little. These countries are : Bolivia, Peru, PNG, Sierra Leone, Togo, and Zambia. All the other countries would have been better off in the absence of a mining industry.

Regarding the other proposals of the dependency school we can conclude that imports do increase. The evidence suggests that this may not have been so beneficial as there is a negative correlation between the non-mining GDP and the imports multipliers. Similarly net foreign factor payments increase considerably. Both these variables, though, return to close to their previous level by the end of the twenty-six periods. Though the capital stock may increase in the short term, it appears that these additions depreciate over time and are not replaced. There does not seem to be any general improvement in either the size of the labor force or the quality of human capital. Large permanent additions to the capital stock did occur in a number of countries : Cameroon, Mexico, Oman, Peru, Togo, Tunisia, and Zambia. Most of these are countries which saw increases in non-mining GNP. Only in Mexico, Oman, Tunisia, and Zimbabwe does mining appear to make an effective contribution to the improvement of the quality of human capital.

More sophisticated approaches could be taken to modeling the long-run behavior of the model [see Granger (1993)]. The Bayesian prior used in this paper is very arbitrary. Also it is likely that the negative effects for countries such as Botswana are short run capacity constraints in the economy. However, in a linear model which does not differentiate between the long-run and the short-run the short-run effects dominate. This paper only addresses a few aspects of the effect of the mining sector on developing economies. In particular, distribution and environmental effects have not been considered. Distribution is unlikely to be improved when income itself is not improved. The environmental effect impact on welfare is certain to be negative. Elsewhere [Stern (1994a), (1994b)] I consider whether income generated by the mining sector is sustainable.

Though the proponents of dependency theory are right in that mining is often a disaster in developing economies, neoclassical policy analysts are also correct in suggesting that some countries can get it right. Future research could apply more sophisticated models to determine what policies have actually been effective in promoting mineral-based development.

Appendix A. Data Sources and Coverage

The sample includes all developing countries as defined in the World Development Report 1992 [IBRD (1992)] which : are not members of OPEC, as it would be expected that the OPEC countries have since 1973 been able to gain a far larger profit share from mineral exploitation than other developing countries and therefore constitute a special case; have a mining sector constituting more than 5% of GDP in at least one of the years 1963-88; had more than 1 million population in 1992, as listed in the World Development Report 1992 [IBRD (1992)]; and have sufficient disaggregated data available for at least ten years of 1963-1988.

The variables collected and sources used are :

GDP (Current Prices)	UN National Accounts [UNO (various years)]
Mining GDP (Current Prices)	UN National Accounts [UNO (various years)]
Gross Fixed Capital Formation (Current Prices)	UN National Accounts [UNO (various years)]
GDP Deflator	IFS [IMF (various years)]
Ratio of GNP to GDP	Penn World Table [Summers and Heston (1991)]
GDP per Capita in Real International Dollars	Penn World Table [Summers and Heston (1991)]
Imports (Nominal Prices)	Penn World Table [Summers and Heston (1991)]
Population	Penn World Table [Summers and Heston (1991)]
Participation Rate	Penn World Table [Summers and Heston (1991)]
Educational Enrolment	World Tables and World Development Report 1992 [IBRD (1990), (1992)]

Generally there was some substitution of data between the above sources to fill in any missing data. Data on educational enrolment were extensively interpolated and extrapolated. All data were collected for the period 1963-1988 with the exceptions noted :

Bolivia	Data coverage 1963-1986.
Botswana	Data coverage 1972-1986.
Cameroon	Data coverage 1975-1988. The GDP deflator was estimated using the Penn World Table.
Liberia	Data coverage 1968-1988.
Oman	Data coverage 1970-1988.
Papua New Guinea	Data coverage 1969-1988.
Peru	Data coverage 1968-1988.
Sierra Leone	Data coverage 1964-1988. The GDP deflator was estimated using the Penn World Table.
Togo	Data coverage 1964-1981.
Zaire	Mining GDP data were only available from 1968 to 1977. A mining output index was available from 1968 to 1984 so the latter was multiplied by the relative price of mining output to GDP in Zambia to obtain an index deflated by the GDP deflator for 1978 to 1984. The GDP deflator was estimated using the Penn World Table.
Zambia	Data coverage 1964-1988.
Zimbabwe	Imports figures for 1966-68 and 1973 were estimated on the basis of merchandise trade figures (IFS) for those years. Data coverage 1964-1988.

Appendix B Construction of Net Capital Stock Series

In few countries was any data available on the size of the capital stock. Where this was available it only covered the 1980s. The size of the net capital stock in the first year (in most cases 1963) was estimated using a formula derived from a regression carried out on all the available data in the Penn World Table. Capital stock is modelled as a translog function of GDP and the labor force :

$$\underset{}{\ln K} = \underset{(5.3730)}{9.0493} + \underset{(0.8771)}{0.5356} \ln Q + \underset{(0.03955)}{0.03331} (\ln Q)^2 - \underset{(0.9944)}{0.5332} \ln L + \underset{(0.03375)}{0.05699} (\ln L)^2 - \underset{(0.07625)}{0.06031} \ln Q \ln L \quad \text{(B-1)}$$

$$\bar{R}^2 = 0.9942 \qquad n = 290 \qquad \chi(5) = 5.1631$$

where K is the net capital stock in 1985 international prices (calculated from the Penn World Table as : KAPW*RDGPCH*POP/RGDPW), Q is GDP in 1985 international prices (RGDPCH*POP), and L is the size of the labor force (RDGPCH*POP/RGDPW). Standard errors of coefficients are in parentheses. The chi-square statistic is for the Breusch-Pagan (1979) test for heteroscedasticity. The estimated capital stock in international prices was converted to local currency in constant 1980 prices.

Net capital stocks in subsequent years, K_T, were calculated using a vintage depreciation method:

$$K_T = \left(\prod_{i=10}^{T+10} d_i \right) K_1 + \sum_{t=1}^{T} \left(\prod_{i=1}^{T-t} d_i \right) I_t \qquad \text{(B-2)}$$

where I_t is the gross fixed capital formation in year t, and d_i the are depreciation factors. It was assumed that the rate of depreciation increases as the age of a particular capital vintage increases so that dd/dt = -.01 ie. in the second year 1% of the vintage is depreciated, in the third year 2% of the capital remaining is depreciated and so forth. This rate implies that the quantity of remaining capital follows a downwardly sloping S curve, and that after 10 years approximately half the initial vintage is depreciated which is why the depreciation rate on the initial capital stock in the first year is set at 10%. These arbitrary choices produced fairly good fits with the estimates in the Penn World Table for 1979-88 for the few countries with available data.

References

Adams, F. and J. Behrman, 1981, The linkage effects of raw material processing in economic development : A survey of modeling and other approaches, Journal of Policy Modeling 3(3), 375-397.

Adler, J. H., 1961, Changes in the role of resources at different stages of economic development, in: J. J. Spengler, ed., Natural resources and economic growth (Resources for the Future, Washington, DC).

Auty, R. M., 1991, Third World response to global processes : The mineral economies, Professional Geographer 43, 68-76.

Baldwin, R. E., 1966, Economic development and export growth : A study of Northern Rhodesia 1920-60 (University of California Press, Berkeley CA).

Banks, S. M., 1992, Natural resource booms and third world development processes : Incorporating the spatial dimension, Paper presented at the 88th Annual Meeting of the Association of American Geographers, San Diego, CA, April 1992.

Barro, R., 1989, Economic growth in a cross section of countries, NBER Working Paper Series No. 3120 (National Bureau of Economic Research, Cambridge, MA).

Benjamin, N., S. Devarajan, and R. Weiner, 1989, The Dutch disease in a developing country : Oil reserves in Cameroon, Journal of Development Economics 30, 71-92.

Bomsel, O., 1992, The political economy of rent in mining countries, in : J. E. Tilton, ed., Mineral wealth and economic development (Resources for the Future, Washington, DC).

Breusch, T. S. and A. R. Pagan, 1979, A simple test for heteroskedasticity and random coefficient variation, Econometrica 47, 1220-1245.

Brower, J. C., 1987, Conflicting goals of mining companies and host governments, in : H. E. Johansen, O. L. Matthews, and G. Rudzitis, eds., Mineral resource development : Geopolitics, economics and policy (Westview Press, Boulder, CO).

Cobbe, J., 1979, Governments and mining companies in developing countries, Westview Special Studies in Social, Political and Economic Development (Westview Press, Boulder, CO).

Corden, W. and J. Neary, 1982, Booming sector and de-industrialisation in a small open economy, The Economic Journal 92, 825-848.

Daniel, P., 1992, Economic policy in mineral exporting countries : What have we learned ?, in : J. E. Tilton, ed., Mineral wealth and economic development (Resources for the Future, Washington, DC).

Doan, T. A., 1989, User's Manual RATS Version 3.02 (VAR Econometrics, Evanston, IL).

Edwards, S., 1993, Openness, trade liberalization, and growth in developing countries, Journal of Economic Literature 31, 1358-1393.

El-Serafy, S., 1989, The proper calculation of income from depletable natural resources, in : Y. J. Ahmad, S. El-Serafy, and E. Lutz, eds., Environmental accounting for sustainable development (The World Bank, Washington, DC).

Emmott, B., 1993, Multinationals : Everybody's favourite monsters, The Economist 27 March 1993, Survey.

Fardmanesh, M., 1991, Terms of trade shocks and structural adjustment in a small open economy : Dutch disease and oil price increases, Journal of Development Economics 34, 339-353.

Feder, G., 1983, On exports and economic growth, Journal of Development Economics 12, 59-73.

Forsyth, P., 1986, Booming sectors and structural change in Australia and Britain : A comparison, in: J. Neary and S. Van Wijnbergen, eds., Natural resources and the macroeconomy (Blackwell, Oxford).

Fozzard, P.M., 1990, Mining development in sub-Saharan Africa : Investment and its relationship to the enabling environment, Natural Resources Forum 14, 97-105.

Fry, J. and C. Harvey, 1974, Copper and Zambia, in: S. R. Pearson and J. Cownie, eds., Commodity exports and African economic development (D.C. Heath, Lexington, MA).

Gelb, A., 1986, From boom to bust - oil exporting countries over the cycle 1970-84, IDS Bulletin 17(4), 22-29.

Gelb A. et al., 1988, Oil windfalls : Blessing or curse ? (Oxford University Press, Oxford).

Girvan, N., 1972, Copper in Chile : A study in conflict between corporate and national economy (Institute of Social and Economic Research, University of the West Indies, Jamaica).

Girvan, N., 1974, Las multinacionales del cobre in Chile, in: R. Ffrench-Davis and E. Tivoni, eds., El cobre en el desarollo nacional (Centro de Estudios de Planification National, Santiago).

Gluschke, W., N. Iwase and S. Zorn, 1980, Mineral resources and the impact of mining on LDCs, in: S. Sideri and S. Johns, eds., Mining for development in the Third World (Pergamon Press, New York).

Granger C. W. J., 1993, What are we learning about the long-run ? Economic Journal 103, 307-317.

Hartwick, J. M., 1977, Intergenerational equity and the investing of rents from exhaustible resources, American Economic Review 66, 972-974.

IBRD, 1992, World Development Report 1992 (Oxford University Press, New York).

IBRD, 1990, World Tables 1989-1990 (Johns Hopkins University Press, Baltimore, MD).

IMF, various years, International financial statistics, yearly reports (International Monetary Fund, Washington, DC).

Killick, T., 1974, The developmental impact of mining activities in Sierra Leone, in: S.R. Pearson and J. Cownie, eds., Commodity exports and African economic development (D.C. Heath, Lexington, MA).

Kindleberger, C. P., 1961, International trade and investment and resource use in economic growth, in: J. J. Spengler, ed., Natural resources and economic growth (Resources for the Future, Washington, DC).

Labys, W., 1980a, Commodity models and their potential for Latin American planning, in : W. C. Labys, M. I. Nadiri, and J. Nuñez del Arco, eds., Commodity markets and Latin American Development : A modeling approach (Ballinger, Cambridge, MA).

Labys, W., 1980b, Market structure, bargaining power and resource price formation (D.C. Heath, Lexington, MA).

Lasaga, M., 1981, The copper industry in the Chilean economy : An econometric analysis (D.C. Heath, Lexington, MA).

Levine, R. and D. Renelt , 1992, A sensitivity analysis of cross-country growth regressions, American Economic Review 82, 942-963.

Lira, R., 1980, The impact of copper in the Chilean economy, in : W. C. Labys, M. I. Nadiri, and J. Nuñez del Arco, eds., Commodity markets and Latin American Development : A modeling approach (Ballinger, Cambridge, MA).

Lucas, R., 1988, On the mechanics of economic development, Journal of Monetary Economics 22, 3-42.

Michaely, M., 1977, Exports and growth : An empirical investigation, Journal of Development Economics 4, 49-54.

Mikesell, R., ed., 1971, Foreign investments in the petroleum and minerals industry : Case studies of investor - host country relations (Johns Hopkins University Press, Baltimore MD).

Mikesell, R., 1974, The copper economy of Zaire, in: S.R. Pearson and J. Cownie, Commodity exports and African economic development (D.C. Heath, Lexington, MA).

Mikesell, R., 1975, Foreign investment in copper mining (Resources for the Future and Johns Hopkins University Press, Baltimore, MD).

Morley, S. and G. Smith, 1977, Limited search and the technology choices of multinational firms in Brazil, Quarterly Journal of Economics 91, 263-288.

Nankani, G., 1979, Development problems of mineral exporting countries, World Bank Staff Working Paper No. 354 (The World Bank, Washington DC).

Nziramasanga, M. and C. Obidegwu, 1981, Impact of copper on economic development of Zambia: An econometric analysis (D.C. Heath, Lexington, MA).

O'Faircheallaigh, C., 1984, Mining and development (Croom Helm, London).

Otani, I. and D. Villaneuva, 1990, Long-term growth in developing countries and its determinants : An empirical analysis, World Development 18, 769-783.

Palma, G., 1978, Dependency : A formal theory of underdevelopment or a methodology for the analysis of concrete situations of underdevelopment ?, World Development 6, 881-916.

Rees, J. A., 1985, Natural resources : Allocation, economics and policy (Methuen, London).

Reuber, G., H. Crookell, M. Emerson and G. Gallais-Hamonno, 1973, Private foreign investment in development (Clarendon Press, Oxford).

Reynolds, C., 1965, Development problems of an export economy : The case of Chile, in: M. Mamlakis and C. Reynolds, eds., Essays on the Chilean economy (R.D. Irwin, Homewood IL).

Romer, P., 1986, Increasing returns and long-run growth, Journal of Political Economy 94, 1002-1037.

Salvatore, D., 1983, A simultaneous equation model of trade and development with dynamic policy simulations, Kyklos 36(1), 66-90.

Sargent, T., 1979, Estimating vector autoregressions using methods not based on explicit economic theories, Federal Reserve Bank of Minneapolis, Quarterly Review 3(3), 8-15.

Schmookler, A. B., 1993, The illusion of choice : How the market economy shapes our destiny (State University of New York Press, Albany, NY).

Sims, C. A., 1980, Macroeconomics and reality, Econometrica 48, 1-48.

Soete, L., 1981, Technological dependency : A critical view, in: D. Seers, ed., Dependency theory : A critical reassessment (Frances Pinter, London).

Solow, R. M., 1974, The economics of resources or the resources of economics, American Economic Review 64, 1-14.

Stern, D. I., 1994a, Natural resources as factors of production : Three empirical studies, Ph.D. Dissertation (Boston University, Boston, MA).

Stern, D. I., 1994b, Is mining income sustainable income in developing countries ? Discussion Paper in Environmental Economics and Environmental Management 9401 (EEEM, University of York, York).

Summers, R. and A. Heston, 1991, The Penn World Table (Mark 5): An expanded set of international comparisons, 1950-1988, Quarterly Journal of Economics 106, 1-41.

Tanzer, M., 1980, The race for resources : Continuing struggles over minerals and fuels (Monthly Review, New York).

Taylor, L., K. Yurukoglu and S. Chaudry, 1986, A macro model of an oil exporter, in: J. Neary and S. Van Wijnbergen, eds., Natural resources and the macroeconomy (Blackwell, Oxford).

Tilton, J. E., ed., 1992, Mineral wealth and economic development (Resources for the Future, Washington, DC).

Unemo L., 1994, Environmental impact of governmental policies and external shocks in Botswana - A CGE-model approach, in : C. A. Perrings, K.-G. Mäler, C. Folke, C.S. Holling, and B.-O. Jansson, eds., Biodiversity conservation (Kluwer Academic Press, Dordrecht) .

U.N.O., various years, National accounts statistics (United Nations, New York).

Warr, P., 1986, Indonesia's other Dutch disease, in: J. Neary and S. Van Wijnbergen, eds., Natural resources and the macroeconomy (Blackwell, Oxford).

Yotopoulos, P. and J. Nugent, 1973, A balanced growth version of the linkage hypothesis : A test, The Quarterly Journal of Economics 87(2), 157-171.

Table 1 Multipliers of Mining GDP on Mining GDP

Country	Multiplier 1	2	5	10	15	20	26	Sum
Bolivia	1.0000	0.6560	0.1753	0.0101	-0.0061	-0.0137	-0.0333	2.5716
Botswana	1.0000	0.8024	0.3931	0.0729	-0.0447	-0.0896	-0.1170	3.1945
Cameroon	1.0000	0.8644	0.5492	0.2398	0.0869	0.0130	-0.0265	6.3425
Chile	1.0000	0.6134	0.1145	-0.0184	-0.0143	-0.0066	-0.0035	2.1851
Colombia	1.0000	0.9005	0.6028	0.2277	0.0150	-0.1029	-0.1870	5.0279
Jamaica	1.0000	0.6926	0.1837	-0.0224	-0.0252	-0.0145	-0.0101	2.4713
Liberia	1.0000	0.7979	0.4241	0.1688	0.0942	0.1046	0.1961	6.5856
Malaysia	1.0000	0.7745	0.3499	0.0630	-0.0405	-0.0914	-0.1283	2.8601
Mexico	1.0000	0.7319	0.2571	0.0238	0.0072	0.0188	0.0242	3.5560
Oman	1.0000	0.7707	0.3602	0.1057	0.0387	0.0289	0.0369	4.7408
Peru	1.0000	0.8026	0.3913	0.0893	0.0074	-0.0008	0.0123	4.4361
PNG	1.0000	0.7492	0.3102	0.0610	0.0035	-0.0062	-0.0052	3.7466
Sierra Leone	1.0000	0.6981	0.1724	-0.0340	-0.0154	0.0093	0.0128	2.6346
South Africa	1.0000	0.7619	0.3128	0.0857	0.0537	0.0357	0.0001	4.4195
Togo	1.0000	0.7033	0.2423	0.0287	-0.0162	-0.0249	-0.0195	2.9569
Tunisia	1.0000	0.8695	0.5537	0.2442	0.1279	0.1022	0.0909	7.5028
Zaire	1.0000	0.7721	0.3422	0.0554	-0.0213	-0.0261	-0.0101	3.6393
Zambia	1.0000	0.6632	0.1893	0.0136	-0.0097	-0.0109	-0.0089	2.7346
Zimbabwe	1.0000	0.7207	0.2545	0.0307	-0.0017	-0.0002	0.0044	3.3441
Mean	1.0000	0.7550	0.3252	0.0761	0.0126	-0.0040	-0.0090	3.9447
St. Dev. of Mean	0.0000	0.0169	0.0310	0.0193	0.0105	0.0121	0.0179	0.3384
T Statistic		44.6123	10.5044	3.9393	1.1973	-0.3284	-0.5058	11.6556

Sum : Sum of all multipliers

Critical values for two-sided t-test : 1%, 2.831; 5%, 2.080; 10%, 1.721.

Table 2 Multipliers of Mining GDP on Non-Mining GDP								
	Multiplier							
Country	1	2	5	10	15	20	26	Adj. Sum
Bolivia	-0.2297	-0.1868	-0.0829	0.0275	0.0640	0.0418	-0.0265	-0.0950
Botswana	-0.5450	-0.4366	-0.2431	-0.1285	-0.0955	-0.0838	-0.0819	-1.2960
Cameroon	-0.7095	-0.5333	-0.1020	0.3812	0.6791	0.8689	1.0154	1.8439
Chile	-1.4864	-0.7894	-0.1337	-0.2043	-0.2023	-0.1324	-0.0895	-2.8896
Colombia	-0.7403	-0.4986	-0.1899	-0.3030	-0.5101	-0.6140	-0.6559	-2.4008
Jamaica	-0.9650	-0.7635	-0.2898	0.0132	0.0011	-0.0433	-0.0382	-1.4904
Liberia	-1.7620	-1.2896	-0.5253	-0.1553	-0.0903	-0.1023	-0.1723	-1.2668
Malaysia	4.4988	3.6082	1.8496	0.5167	-0.0912	-0.4965	-0.8934	5.0423
Mexico	-1.0594	-0.8526	-0.4455	-0.1425	-0.0431	-0.0085	0.0285	-1.4595
Oman	-0.6357	-0.3646	0.0150	0.1160	0.1093	0.1138	0.1363	0.2384
Peru	-1.7154	-1.1741	-0.2076	0.2420	0.2142	0.1176	0.0350	-0.2844
PNG	0.0221	0.0156	-0.0031	-0.0139	-0.0114	-0.0078	-0.0059	-0.0426
Sierra Leone	-0.8292	-0.6481	-0.2146	0.0468	0.0326	-0.0116	-0.0226	-0.9413
South Africa	-0.9507	-0.6010	-0.1277	-0.0592	-0.1161	-0.1383	-0.1183	-1.0112
Togo	0.3194	0.1902	0.0504	0.0737	0.1280	0.1617	0.1761	1.1302
Tunisia	0.0314	0.1474	0.4474	0.7479	0.8191	0.7729	0.7048	2.2484
Zaire	-0.7750	-0.5894	-0.1145	0.2559	0.1775	-0.0559	-0.2360	-0.2978
Zambia	-0.5369	-0.3578	-0.0852	0.0115	0.0113	0.0027	-0.0040	-0.4826
Zimbabwe	-1.7586	-1.2413	-0.4287	-0.1361	-0.0597	0.0163	0.0702	-1.8350
Mean	-0.5172	-0.3350	-0.0437	0.0679	0.0535	0.0211	-0.0094	-0.2784
St. Dev. of Mean	0.3021	0.2331	0.1127	0.0588	0.0652	0.0759	0.0901	0.4117
T Statistic	-1.7120	-1.4375	-0.3881	1.1548	0.8207	0.2780	-0.1040	-0.6763

Adj. Sum : Sum of all multipliers deflated by the sum of the induced mining GDP

Critical values for two-sided t-test : 1%, 2.831; 5%, 2.080; 10%, 1.721.

Table 3 Multipliers of Mining GDP on Net Foreign Factor Payments

Country	Multiplier 1	2	5	10	15	20	26	Adj. Sum
Bolivia	0.0678	0.0489	0.0169	0.0030	0.0050	0.0080	0.0055	0.1249
Botswana	0.3354	0.2989	0.2022	0.0886	0.0234	-0.0125	-0.0368	0.6406
Cameroon	0.1109	0.1278	0.1371	0.0904	0.0320	-0.0137	-0.0487	0.2031
Chile	-0.0425	-0.0837	-0.1128	-0.0795	-0.0504	-0.0340	-0.0240	-0.7306
Colombia	1.1090	1.0946	0.9747	0.7054	0.4603	0.2416	-0.0041	2.8504
Jamaica	0.0314	0.0058	-0.0480	-0.0729	-0.0530	-0.0231	0.0023	-0.3774
Liberia	0.0284	0.0247	0.0421	0.0904	0.1452	0.2279	0.4056	0.6094
Malaysia	0.7349	0.5610	0.2407	0.0405	-0.0223	-0.0535	-0.0819	0.7504
Mexico	0.0412	0.0320	0.0057	-0.0105	-0.0021	0.0106	0.0216	0.0507
Oman	-0.1425	-0.1059	-0.0524	-0.0193	0.0079	0.0321	0.0547	-0.0479
Peru	0.2221	0.0843	-0.0839	-0.0731	-0.0247	-0.0008	0.0077	-0.1132
PNG	0.1854	0.1348	0.0539	0.0153	0.0062	0.0026	0.0003	0.1992
Sierra Leone	0.0298	0.0045	-0.0143	0.0013	0.0050	0.0005	-0.0024	-0.0010
South Africa	-0.0041	0.0013	0.0106	0.0165	0.0171	0.0128	0.0026	0.0674
Togo	-0.0266	0.0061	0.0990	0.2114	0.2549	0.2399	0.1794	1.6058
Tunisia	-0.1093	-0.0843	-0.0267	0.0244	0.0411	0.0454	0.0507	0.0536
Zaire	-0.0324	0.0019	0.1043	0.2111	0.2014	0.1118	-0.0225	0.8508
Zambia	0.0936	0.0642	0.0195	0.0033	-0.0001	-0.0024	-0.0041	0.0963
Zimbabwe	-0.2091	-0.1691	-0.0768	-0.0161	-0.0010	0.0045	0.0068	-0.2501
Mean	0.1275	0.1078	0.0785	0.0647	0.0550	0.0420	0.0270	0.3465
St. Dev. of Mean	0.0700	0.0641	0.0528	0.0391	0.0284	0.0207	0.0236	0.1774
T Statistic	1.8232	1.6803	1.4854	1.6560	1.9382	2.0251	1.1447	1.9529

Adj. Sum : Sum of all multipliers deflated by the sum of the induced mining GDP
Critical values for two-sided t-test : 1%, 2.831; 5%, 2.080; 10%, 1.721.

Table 4 Multipliers of Mining GDP on GNP

Country	Multiplier 1	2	5	10	15	20	26	Adj. Sum
Bolivia	0.7024	0.4203	0.0755	0.0346	0.0529	0.0201	-0.0653	0.7801
Botswana	0.1196	0.0669	-0.0521	-0.1442	-0.1635	-0.1610	-0.1620	-0.9435
Cameroon	0.1797	0.2032	0.3100	0.5306	0.7339	0.8955	1.0376	2.6408
Chile	0.6423	0.2840	-0.2867	-0.6403	-0.8445	-1.0364	-1.2649	-8.1264
Colombia	-0.3431	-0.0139	0.5446	1.0267	1.4150	1.7710	2.1405	6.2635
Jamaica	1.1651	0.5011	-0.5212	-1.1363	-1.5255	-1.9118	-2.3678	-13.1512
Liberia	-0.7903	-0.5164	-0.1432	-0.0769	-0.1413	-0.2256	-0.3818	-0.8762
Malaysia	4.7639	3.8216	1.9587	0.5392	-0.1094	-0.5345	-0.9398	5.2919
Mexico	-0.1005	-0.1527	-0.1941	-0.1082	-0.0338	-0.0003	0.0311	-0.5103
Oman	0.5068	0.5120	0.4277	0.2410	0.1401	0.1106	0.1186	1.2863
Peru	-0.9374	-0.4558	0.2676	0.4044	0.2464	0.1176	0.0395	0.8287
PNG	0.8367	0.6300	0.2533	0.0318	-0.0141	-0.0166	-0.0114	0.7582
Sierra Leone	0.1411	0.0455	-0.0279	0.0115	0.0122	-0.0029	-0.0073	0.0597
South Africa	0.0533	0.1596	0.1746	0.0099	-0.0795	-0.1154	-0.1207	-0.0786
Togo	1.3460	0.8874	0.1936	-0.1089	-0.1432	-0.1030	-0.0228	0.5245
Tunisia	1.1407	1.1012	1.0278	0.9677	0.9060	0.8297	0.7450	3.1948
Zaire	0.2574	0.1808	0.1233	0.1002	-0.0452	-0.1938	-0.2237	-0.1486
Zambia	0.3695	0.2412	0.0846	0.0218	0.0017	-0.0059	-0.0087	0.4211
Zimbabwe	-0.5495	-0.3515	-0.0973	-0.0893	-0.0603	0.0116	0.0678	-0.5849
Mean	0.5002	0.3981	0.2168	0.0850	0.0183	-0.0290	-0.0735	-0.1247
St. Dev. of Mean	0.2708	0.2075	0.1204	0.1106	0.1349	0.1647	0.2002	0.9552
T Statistic	1.8469	1.9185	1.8006	0.7683	0.1357	-0.1761	-0.3671	-0.1306

Adj. Sum : Sum of all multipliers deflated by the sum of the induced mining GDP
Critical values for two-sided t-test : 1%, 2.831; 5%, 2.080; 10%, 1.721.

Table 5 Multipliers of Mining GDP on Imports

Country	Multiplier 1	2	5	10	15	20	26	Adj. Sum
Bolivia	0.3801	0.2303	0.0498	0.0257	0.0306	0.0198	0.0056	0.5247
Botswana	-0.4256	-0.3745	-0.2458	-0.1097	-0.0458	-0.0228	-0.0200	-0.9534
Cameroon	-0.7039	-0.5802	-0.2963	-0.0310	0.0809	0.1159	0.1139	-0.2488
Chile	0.3210	0.3783	0.2118	-0.0292	-0.0471	-0.0261	-0.0247	0.5541
Colombia	0.2032	0.3285	0.4030	0.1994	0.0286	0.0519	0.0944	0.8433
Jamaica	0.2511	0.2780	0.2155	0.0600	-0.0071	-0.0145	0.0011	0.7304
Liberia	-0.9205	-0.5753	0.0228	0.3087	0.3045	0.2593	0.2652	0.5708
Malaysia	0.4543	0.4595	0.3984	0.1750	-0.0953	-0.3667	-0.6614	-0.3262
Mexico	-0.1495	-0.1721	-0.1583	-0.0798	-0.0483	-0.0519	-0.0632	-0.6349
Oman	-0.4537	-0.2202	0.0490	0.0588	0.0327	0.0315	0.0406	0.0465
Peru	-0.7217	-0.4636	0.0065	0.2207	0.1891	0.1235	0.0678	0.3670
PNG	-0.0802	-0.0627	-0.0253	-0.0019	0.0001	-0.0024	-0.0049	-0.0863
Sierra Leone	-0.0957	0.0431	0.2005	0.1409	0.0365	-0.0176	-0.0208	0.5995
South Africa	-0.0300	0.1909	0.2913	0.0843	-0.0164	-0.0475	-0.0550	0.3254
Togo	2.2527	1.6689	0.6768	0.1128	-0.0343	-0.0526	-0.0098	2.6206
Tunisia	0.8100	0.6579	0.2206	-0.1505	-0.0633	0.1807	0.3806	0.5295
Zaire	-0.0742	-0.0351	0.0357	0.0231	-0.0578	-0.1193	-0.1374	-0.3523
Zambia	-0.3041	-0.0932	0.0704	0.0346	0.0135	0.0088	0.0080	0.0728
Zimbabwe	0.3669	0.4761	0.4166	0.1172	0.0114	0.0039	0.0110	1.0854
Mean	0.0568	0.1123	0.1339	0.0610	0.0164	0.0039	-0.0005	0.3299
St. Dev. of Mean	0.1557	0.1171	0.0543	0.0263	0.0210	0.0284	0.0443	0.1716
T Statistic	0.3651	0.9594	2.4667	2.3212	0.7835	0.1368	-0.0107	1.9226

Adj. Sum : Sum of all multipliers deflated by the sum of the induced mining GDP
Critical values for two-sided t-test : 1%, 2.831; 5%, 2.080; 10%, 1.721.

Table 6 Multipliers of Mining GDP on the Capital Stock

	Multiplier							
Country	1	2	5	10	15	20	26	Adj. LRM
Bolivia	0.1146	0.1120	0.0973	0.0980	0.0907	0.0057	-0.2435	-0.0947
Botswana	-0.1143	-0.1597	-0.2411	-0.2781	-0.2807	-0.2923	-0.3338	-0.1045
Cameroon	-0.4755	-0.3441	-0.0485	0.2123	0.3056	0.3184	0.2935	0.0463
Chile	-0.2083	-0.1130	0.0344	-0.0040	-0.0857	-0.1169	-0.1281	-0.0586
Colombia	-0.4280	-0.2141	0.0545	-0.2111	-0.7206	-1.1825	-1.6322	-0.3246
Jamaica	-0.0564	-0.0658	0.1327	0.4767	0.4638	0.2624	0.0600	0.0243
Liberia	-1.1135	-1.1449	-1.1203	-1.1021	-1.3941	-2.1410	-3.9094	-0.5936
Malaysia	0.0366	0.6881	1.7409	1.7995	0.8752	-0.5022	-2.4075	-0.8417
Mexico	0.1900	0.0950	-0.1304	-0.2290	-0.1188	0.0459	0.2519	0.0708
Oman	-0.2261	-0.1185	0.1030	0.2265	0.2442	0.2687	0.3335	0.0704
Peru	-0.7214	-0.7236	-0.5996	-0.2823	-0.0314	0.1310	0.2495	0.0562
PNG	0.1577	0.0567	-0.0882	-0.1103	-0.0790	-0.0566	-0.0467	-0.0125
Sierra Leone	0.1137	0.1063	0.0539	0.0051	-0.0076	-0.0175	-0.0281	-0.0107
South Africa	-0.4755	-0.3746	-0.0429	0.2754	0.2994	0.1260	-0.2181	-0.0494
Togo	1.4656	1.6032	1.8048	1.6835	1.2932	0.8736	0.5367	0.1815
Tunisia	0.3121	1.0299	2.2510	2.4969	2.2699	2.3841	2.8148	0.3752
Zaire	-0.0946	-0.2042	-0.3192	-0.1629	0.0248	0.0735	-0.0081	-0.0022
Zambia	-0.2574	-0.1938	-0.0217	0.1310	0.1749	0.1745	0.1615	0.0591
Zimbabwe	-0.5000	-0.2463	0.1624	0.1899	0.0523	0.0044	0.0379	0.0113
Mean	-0.1200	-0.0111	0.2012	0.2745	0.1777	0.0189	-0.2219	-0.0630
St. Dev. of Mean	0.1164	0.1339	0.1858	0.1886	0.1669	0.1904	0.2959	0.0602
T Statistic	-1.0312	-0.0831	1.0830	1.4551	1.0644	0.0992	-0.7499	-1.0462

Adj. LRM : Long-Run Effect on capital accumulation adjusted for induced change in mining GDP.

Critical values for two-sided t-test : 1%, 2.831; 5%, 2.080; 10%, 1.721.

Table 7 Multipliers of Mining GDP on the Labor Force

Country	Multiplier 1	2	5	10	15	20	26	Adj. LRM
Bolivia	7.81E-06	7.49E-06	7.47E-06	8.51E-06	1.01E-05	1.16E-05	1.15E-05	4.46E-06
Botswana	3.12E-07	-1.95E-07	-1.51E-06	-3.24E-06	-4.67E-06	-6.01E-06	-7.76E-06	-2.43E-06
Cameroon	-9.26E-07	-1.13E-06	-1.47E-06	-1.53E-06	-1.33E-06	-1.03E-06	-5.92E-07	-9.33E-08
Chile	-5.50E-06	-6.27E-06	-6.55E-06	-5.25E-06	-4.62E-06	-4.77E-06	-5.47E-06	-2.50E-06
Colombia	-7.37E-06	-1.11E-05	-2.00E-05	-3.00E-05	-3.73E-05	-4.40E-05	-5.20E-05	-1.03E-05
Jamaica	-1.70E-05	-1.76E-05	-1.67E-05	-1.02E-05	-2.30E-06	3.25E-06	6.06E-06	2.45E-06
Liberia	-5.89E-06	-4.31E-06	1.93E-06	1.35E-05	2.64E-05	4.40E-05	7.87E-05	1.19E-05
Malaysia	4.81E-06	4.55E-06	9.97E-07	-1.02E-05	-2.41E-05	-3.80E-05	-5.23E-05	-1.83E-05
Mexico	-1.43E-06	-2.69E-06	-4.77E-06	-5.40E-06	-4.71E-06	-3.40E-06	-1.02E-06	-2.86E-07
Oman	3.68E-07	6.47E-07	1.29E-06	2.10E-06	2.80E-06	3.50E-06	4.45E-06	9.39E-07
Peru	3.01E-06	1.90E-06	1.19E-06	3.42E-06	6.04E-06	8.03E-06	9.70E-06	2.19E-06
PNG	-6.68E-07	-8.03E-07	-1.12E-06	-1.47E-06	-1.73E-06	-1.98E-06	-2.32E-06	-6.19E-07
Sierra Leone	-1.02E-06	-9.85E-07	-7.95E-07	-8.82E-07	-1.28E-06	-1.63E-06	-1.95E-06	-7.38E-07
South Africa	-1.02E-05	-9.59E-06	-8.74E-06	-8.89E-06	-8.50E-06	-6.75E-06	-3.56E-06	-8.05E-07
Togo	-2.18E-06	7.89E-07	8.85E-06	2.16E-05	3.31E-05	4.20E-05	4.87E-05	1.65E-05
Tunisia	5.90E-06	7.84E-06	1.20E-05	1.90E-05	2.97E-05	4.26E-05	5.73E-05	7.64E-06
Zaire	-2.07E-05	-2.32E-05	-2.75E-05	-2.96E-05	-3.33E-05	-4.23E-05	-6.00E-05	-1.65E-05
Zambia	-4.45E-07	-3.24E-07	-2.38E-07	-6.19E-07	-1.31E-06	-2.16E-06	-3.42E-06	-1.25E-06
Zimbabwe	7.79E-06	7.00E-06	5.57E-06	6.02E-06	8.09E-06	1.03E-05	1.27E-05	3.80E-06
Mean	-2.28E-06	-2.52E-06	-2.64E-06	-1.74E-06	-4.62E-07	6.98E-07	2.04E-06	-2.07E-07
St. Dev. of Mean	1.70E-06	1.82E-06	2.21E-06	2.98E-06	4.12E-06	5.55E-06	7.70E-06	1.86E-06
T Statistic	-1.3442	-1.3824	-1.1928	-0.5839	-0.1123	0.1258	0.2649	-0.1115

Adj. LRM : Long-Run Effect on the size of the labor force adjusted for induced change in mining GDP.

Critical values for two-sided t-test : 1%, 2.831; 5%, 2.080; 10%, 1.721.

The increase in mining GDP is one real 1980 international dollar.

Table 8 Multipliers of Mining GDP on the Quality of Human Capital

	Multiplier							
Country	1	2	5	10	15	20	26	Adj. LRM
Bolivia	1.72E-11	1.68E-11	1.54E-11	1.25E-11	8.52E-12	3.18E-12	-5.51E-12	-2.14E-12
Botswana	-1.05E-10	-6.74E-11	-4.15E-12	1.78E-11	6.32E-12	-9.65E-12	-2.57E-11	-8.05E-12
Cameroon	7.77E-12	7.31E-12	6.32E-12	5.11E-12	4.00E-12	2.97E-12	1.96E-12	3.08E-13
Chile	-1.02E-11	-1.13E-11	-1.02E-11	-4.20E-12	-6.30E-13	1.91E-13	-1.71E-13	-7.81E-14
Colombia	-2.09E-11	-2.05E-11	-2.15E-11	-2.21E-11	-1.77E-11	-1.04E-11	-1.38E-12	-2.74E-13
Jamaica	1.20E-11	2.25E-11	2.76E-11	9.01E-12	-1.72E-12	-1.87E-12	1.34E-12	5.43E-13
Liberia	2.13E-10	9.10E-11	-6.56E-11	-8.17E-11	-6.16E-11	-6.54E-11	-1.10E-10	-1.67E-11
Malaysia	9.54E-12	8.42E-12	4.14E-12	-1.86E-12	-5.34E-12	-7.15E-12	-7.90E-12	-2.76E-12
Mexico	7.44E-13	5.08E-13	1.17E-13	7.20E-14	2.90E-13	5.43E-13	8.24E-13	2.32E-13
Oman	9.49E-12	1.07E-11	1.19E-11	1.15E-11	1.24E-11	1.49E-11	1.94E-11	4.10E-12
Peru	-6.84E-12	-5.19E-12	-2.18E-12	-1.70E-13	6.23E-13	1.08E-12	1.45E-12	3.26E-13
PNG	9.12E-12	6.41E-12	2.01E-12	-1.72E-13	-6.72E-13	-8.69E-13	-1.05E-12	-2.81E-13
Sierra Leone	-2.20E-11	-2.30E-11	-1.80E-11	-7.18E-13	8.05E-12	5.90E-12	-8.93E-13	-3.39E-13
South Africa	-1.62E-13	-2.04E-13	-2.12E-13	-2.84E-13	-5.00E-13	-7.23E-13	-8.43E-13	-1.91E-13
Togo	4.22E-10	3.12E-10	7.30E-11	-1.70E-10	-2.87E-10	-2.97E-10	-2.15E-10	-7.27E-11
Tunisia	8.05E-13	1.07E-11	2.78E-11	2.73E-11	1.62E-11	1.25E-11	1.89E-11	2.52E-12
Zaire	-1.47E-11	-2.63E-12	9.98E-12	-2.24E-12	-1.51E-11	-1.67E-11	-1.05E-11	-2.88E-12
Zambia	7.75E-12	1.12E-11	1.23E-11	7.05E-12	2.83E-12	5.02E-13	-7.06E-13	-2.58E-13
Zimbabwe	-2.30E-10	-1.52E-10	-1.08E-11	5.44E-11	5.11E-11	3.95E-11	3.03E-11	9.06E-12
Mean	1.58E-11	1.13E-11	3.04E-12	-7.30E-12	-1.47E-11	-1.73E-11	-1.61E-11	-4.71E-12
St. Dev. of Mean	2.81E-11	1.92E-11	5.93E-12	1.05E-11	1.54E-11	1.57E-11	1.24E-11	3.84E-12
T Statistic	0.5632	0.5885	0.5132	-0.6975	-0.9553	-1.0988	-1.2910	-1.2261

Adj. LRM : Long-Run Effect on the quality of human capital adjusted for induced change in mining GDP.

Critical values for two-sided t-test : 1%, 2.831; 5%, 2.080; 10%, 1.721.

The increase in mining GDP is one real 1980 international dollar.

Figure 1. Growth Rate of Non-Mining GDP by Growth Rate of Mining GDP

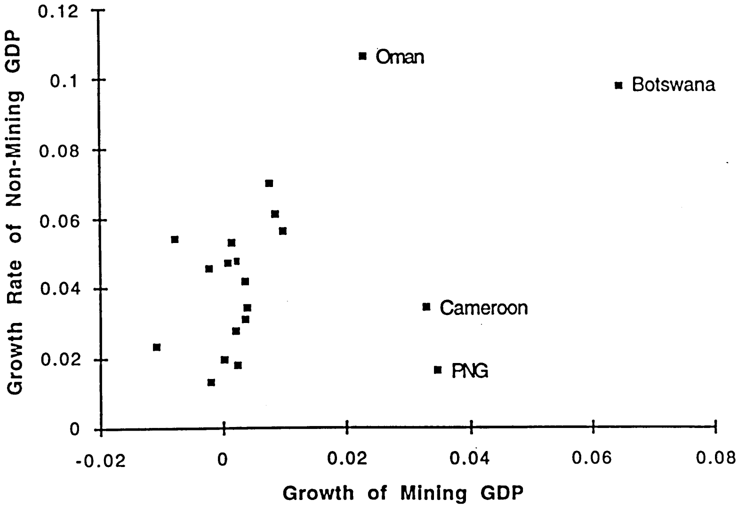


Figure 2. Growth Rate of Net Foreign Factor Payments by Growth of Mining GDP

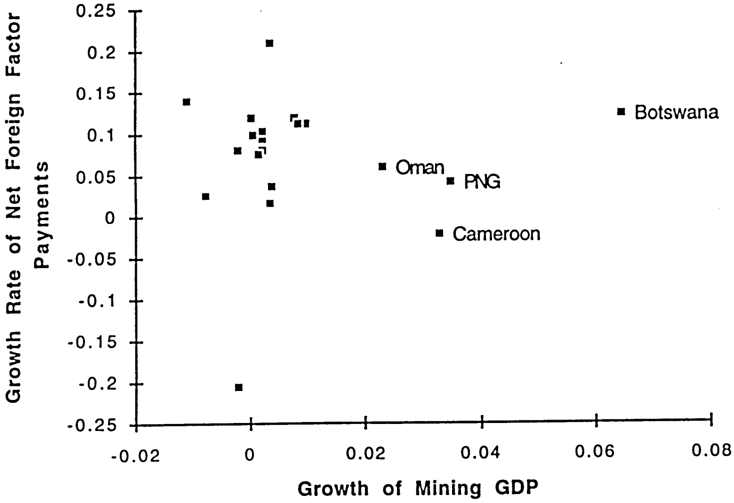


Figure 3. Growth Rate of Imports by Growth of Mining GDP

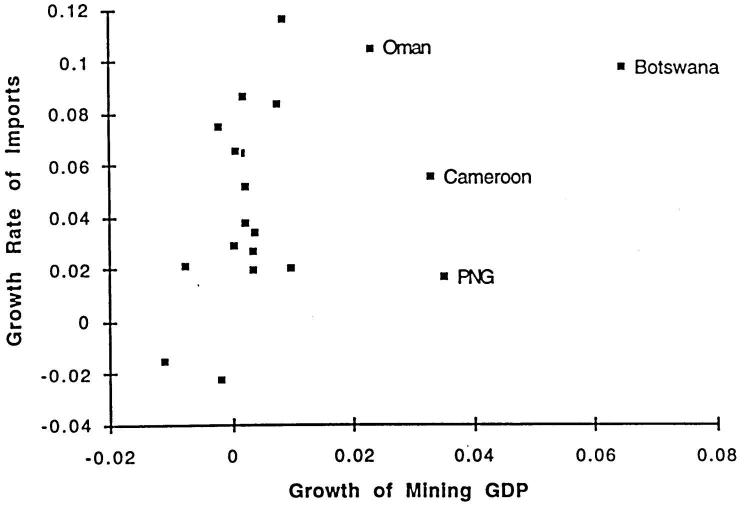


Figure 4. Growth Rate of Capital by Growth of Mining GDP

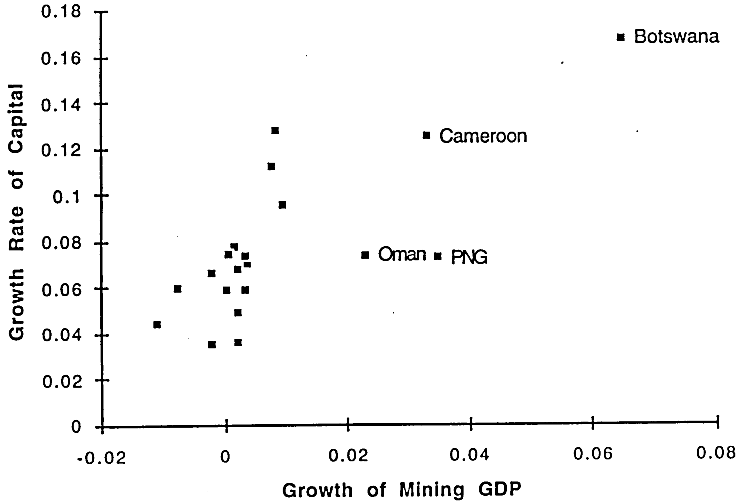
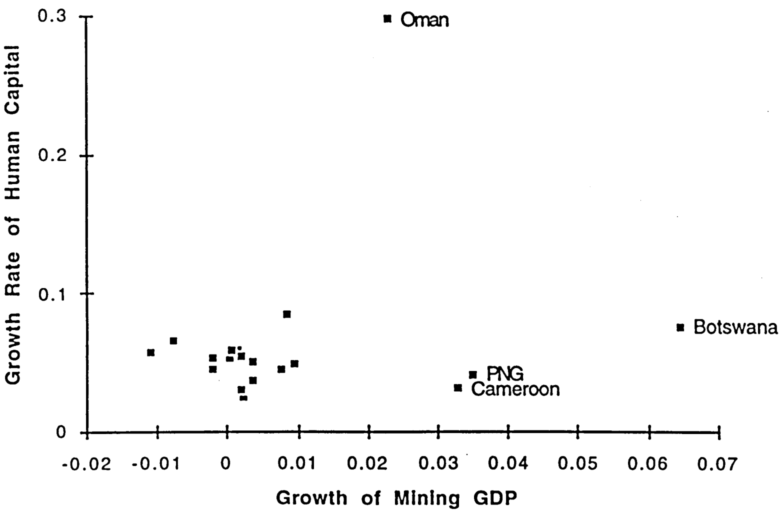


Figure 5. Growth Rate of Human Capital by Growth of Mining GDP



EEEM working papers

9301 Perrings C. and Pearce D.W. Biodiversity conservation and sustainable development

9302 Halkos G. Optimal abatement of sulphur emissions in Europe

9303 Perrings C. Biotic diversity, sustainable development and natural capital

9304 Halkos G. Economic incentives for the implementation of optimal sulphur abatement strategies in Europe

9305 Halkos G. An evaluation of the cost of abatement under the main desulphurisation strategies

9306 Perrings C. and Walker B. Biodiversity loss and the economics of discontinuous change in semi-arid rangelands

9307 Common M. A cost effective environmentally adjusted performance indicator

9308 Barbier E.B. The role of trade interventions in the sustainable management of key resources: the cases of African elephant ivory and tropical timber

9309 Blamey R. and Common M. Stepping back from contingent valuation

9310 Barbier E.B. and Burgess J. Timber trade and tropical deforestation: global trends and evidence from Indonesia

9311 Stern D.I. Measurement unit invariant coefficients in multiplicative-logarithmic functions

9401 Stern D.I. Is mining income sustainable income in developing countries ?

9402 Stern D.I. The effect of the mining sector on developing economies

The purpose of this series is to circulate work in progress by members of the Department of Environmental Economics and Environmental Management at the University of York.

Price of individual Discussion Papers including postage is £2.00 for purchasers in the European Union (EU) and £3.00 for those outside the EU paid by cheque on a UK bank or international money order. We are also interested in entering into exchange arrangements with academic departments and other institutions publishing working papers in related areas.

Enquiries should be addressed to:

The Editor
EEEM Discussion Papers
Department of Environmental Economics and Environmental Management
University of York
York
YO1 5DD