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AND ECONOMIC SUSTAINABILITY
IN MALAYSIA**

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RESOURCE DEPLETION AND ECONOMIC SUSTAINABILITY IN MALAYSIA

Abstract

Countries richly endowed with natural resources have, on average, developed less rapidly than countries that are poor in natural resources. Among the several possible explanations for this phenomenon is a failure to invest sufficiently in reproducible capital to offset the depletion of natural capital. This requirement for economic sustainability can be empirically investigated by analyzing modified measures of net investment and net domestic product. Estimation of these measures involves calculating the economic depreciation of natural resources, a task that has been problematic in previous studies. Malaysia provides an ideal case for such empirical investigations, as it is one of the world's most resource-rich countries yet also has one of the world's fastest growing economies, consists of three subnational regions that differ significantly in terms of economic structure, and has sufficient data for estimating conceptually correct measures of natural resource depletion. Results of the analysis indicate that Malaysia has developed sustainably, despite substantial resource depletion. This is not the case in two of the regions, however, where trends in both net investment and net domestic product indicate that current consumption levels cannot be sustained. Nevertheless, the regional differences in sustainability might be consistent with optimal national use of the rents generated by exploitation of the country's natural resources.

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RESOURCE DEPLETION AND ECONOMIC SUSTAINABILITY IN MALAYSIA

1 Introduction

One might expect countries with abundant natural resources to have a natural advantage in economic development. Yet, the historical record suggests otherwise. In the early 1960s, resource-rich Burma, the Philippines, and Sri Lanka were the three Asian countries that development experts expected to flourish, but they were vastly outperformed over the next thirty years by the resource-poor "tigers" (Hong Kong, Singapore, South Korea, Taiwan). Sub-Saharan Africa is rich in minerals, timber, and land, but it has suffered negative economic growth rates since the mid-1960s. A recent cross-country econometric study by Sachs and Warner (1995) rigorously confirmed that per capita GDP has grown less rapidly throughout the world in resource-rich countries than in resource-poor countries.

There are several possible explanations for the apparent curse of natural resources. One is simply a measurement issue. The GDP growth rate is the weighted average of growth rates in individual sectors. In a simple theoretical model of optimal resource depletion, output and value-added decline over time.[1] Two countries with equally vibrant nonresource sectors would therefore be expected to have different GDP growth rates if one has, in addition, a resource sector, with the growth rate of that country being lower.

This explanation is not entirely satisfying, however. It implies that resource-rich

[1]Consider, for example, a model of nonrenewable resource extraction in which resource price is constant and marginal extraction cost increases with output (Gray's model; see Hartwick and Olewiler 1986, Chapter 3). To satisfy Hotelling's Rule, output must decline over time, thus causing value-added to decline as well.

countries should have a higher per capita GDP — albeit one that is growing less rapidly — than resource-poor countries, because the former have greater total factor endowments. Although small, oil-rich states like Brunei and those in the Persian Gulf appear to confirm this prediction, the many resource-rich developing countries that are poor clearly contradict it. A possible explanation for the failure to parlay resource endowments into a permanently higher GDP is "Dutch disease": a booming resource sector obstructs the growth of nonresource sectors by driving up the real exchange rate (Corden and Neary 1982). Sachs and Warner (1995) have demonstrated that Dutch disease can indeed cause a permanent reduction in GDP when technical change is endogenous (in their model, when technical change is linked to employment in the manufacturing sector).

Two other explanations relate to conditions within resource sectors. The first is, like Dutch disease, a familiar one in the development literature: that export earnings of resource-rich countries have been eroded over time by declining prices of resource-based commodities. Prices of such commodities have indeed declined (Barnett and Morse 1963, Smith 1979, Nordhaus 1992). This has been variously interpreted as indicating that resources are becoming less scarce, that resource markets are inefficient (they ignore user costs), or that importers control commodity markets. In any event, falling export earnings can certainly drag down GDP growth.

The second resource-related explanation is that resource-rich countries have not invested enough to offset the depletion of their natural capital stocks. Natural resources are a form of capital, which, if depleted, must either be replenished or substituted if countries are to expand their asset base and thus earn a rising dividend in the form of GDP growth (Weitzman 1976, Hartwick 1977, Dasgupta and Heal 1979, Solow 1986). Countries that fail to do this might achieve high rates of GDP growth for a short period, but they will not be able to do so on a sustained basis.

These four explanations are not necessarily the only ones, nor are they mutually exclusive. For example, declining resource prices imply that resource-rich countries need to invest more to sustain their consumption, and by extension to achieve a target GDP growth rate, than they would if prices were constant or rising (Vincent, Panayotou, and Hartwick 1995). In fact, all four explanations are probably involved in the dismal growth record of resource-rich countries, with their relative importance varying from country to country.

This paper focuses on the fourth explanation. It examines the case of Malaysia, which is a particularly interesting country because it appears to be immune to the curse of resource-richness. Malaysia is one of the most resource-rich countries in the world. During most of the 1970s and 1980s, it was the world's largest producer and exporter of tin, tropical timber, natural rubber, and palm oil. It was also a significant producer of oil, natural gas, marine fish, pepper, and cocoa. Nevertheless, its per capita GDP growth rate during 1965-90, 4.0 percent per year, was the twelfth highest in the world (World Bank 1992a). It has been even higher in the 1990s.

But the very extraordinariness of Malaysia's resource-richness raises a troubling question: is the country indeed on a sustainable growth path, or has it managed to keep growing simply by developing new resources? It had the good fortune to discover sizable offshore oil fields just before the first oil shock in the early 1970s; consequently, annual crude oil production rose by a factor of more than thirty during 1970-90. During the same period, the annual timber harvest doubled, the annual fish catch tripled, and the country discovered, and developed, huge reserves of natural gas.

Malaysia is also an interesting case because it offers an opportunity to investigate the sustainability issue not only nationally but also at a subnational level. Its three principal regions — Peninsular Malaysia in the west, immediately south of Thailand, and Sabah and Sarawak across the South China Sea on the north coast of Borneo — all had economies dominated by primary sectors in the 1960s. Today, however, Peninsular Malaysia's economy is dominated by manufacturing, while Sabah's and Sarawak's remain overwhelmingly resource-based. In 1970, primary sectors accounted for 40-50 percent of GDP in all three regions; by 1990, they accounted for only 20 percent in Peninsular Malaysia, but they had risen to 60 percent in Sabah and Sarawak. Despite these differences, real per capita GDP grew rapidly in all three regions, 3.8 percent per year in Peninsular Malaysia, 3.4 percent per year in Sarawak, and 2.9 percent per year in Sabah. Are these rates likely to be equally sustainable? The lower rates for the two Borneo states suggest that the answer might not be positive.

The paper is organized as follows. The next section lays out the theoretical underpinnings of the analysis. Two theoretically equivalent are presented, one based on net investment and the other based on net domestic product (NDP). The following section then applies these approaches to Malaysian data at both national and subnational levels. This application overcomes a measurement problem, related to the economic depreciation of natural resources, that has plagued previous applied work. The last section summarizes the limitations of the analysis and draws out its policy implications.

2 Theoretical concepts

The links between natural resource depletion and economic sustainability are well-developed in the theoretical economics literature. This literature suggests two approaches to measuring economic sustainability. Both aim at measuring the impacts of resource depletion on long-run human welfare, i.e. consumption broadly defined. They require identical calculations, so if one approach is feasible, both are. Applying both approaches is useful because in practice they might not give the same answer, although in theory they should.

The first approach, which derives from work by Hartwick (1977), is to estimate the value of the net change in the total capital stock. Letting K_t, H_t, and R_t denote the values of physical, human, and natural capital stocks in period t, respectively, the value of the net change in the total capital stock is given by:

$$I^N_t = dK_t/dt + dH_t/dt + dR_t/dt. \qquad (1)$$

Each item on the right is the difference between gross investment in the indicated form of capital and its economic depreciation. If $I^N_t = 0$, then a country just maintains its total capital stock and can sustain its consumption level. This result has come to be called "Hartwick's Rule." An increase in consumption is possible only if $I^N_t > 0$.

Hartwick (1977, 1990; see also Hartwick and Hagemann 1993) demonstrated that the appropriate measure of dR_t/dt for a nonrenewable resource is the product of marginal rent and the change in the resource stock, which equals the negative of the amount extracted:

$$dR_t/dt = -[p-c'(q_t)]q_t. \qquad (2)$$

p is price of the extracted resource, which for simplicity is assumed to be constant,[2] $c'(q_t)$ is marginal extraction cost, and q_t the quantity extracted. Hartwick refers to the product of marginal rent and quantity extracted as "Hotelling rent." Note that Hotelling rent is smaller than total resource rent, $pq_t-c(q_t)$ (see Figure 1). When resource extraction begins, marginal rent is

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[2]Vincent, Panayotou, and Hartwick (1995) relax this assumption.

low (due to Hotelling's Rule), and the ratio of Hotelling rent to total rent is therefore also low. As extraction proceeds, the ratio rises, reaching 1 at the point of resource exhaustion. We will make use of this ratio in the empirical analysis.

Analogy to a sinking fund provides an intuitive explanation of the link between Hotelling rent and economic depreciation (Hartwick and Hagemann 1993). If a mine owner invests the Hotelling rent in an interest-bearing account each year, then by the time the mine is exhausted he will have accumulated sufficient funds to purchase an equally valuable mine and sustain his mining business. The proportion of resource rents he needs to invest in the sinking fund rises over time because the payments have less and less time to earn interest before the mine is exhausted.

Dasgupta and Mäler (1991) and Mäler (1991) demonstrated that equation (1) needs to be modified in a straightforward way when the resource is renewable:

$$dR_t/dt = -[p-c'(q_t)](q_t-g_t). \qquad (3)$$

g_t is growth of the resource. This modification does not apply to discoveries of nonrenewable resources, however, which represent a change in information about resource stocks and not a change in the stocks *per se*. The value of the change in information is reflected in changes in marginal rents and quantities extracted as the country adjusts its optimal extraction schedule (Hartwick and Hagemann 1993).

The second approach was stimulated by work by Weitzman (1976) on NDP. NDP differs from GDP in that it includes net, not gross, investment:[3]

$$NDP_t = C_t + I^N_t, \qquad (4)$$

[3]These expressions assume, for simplicity, that trade is balanced.

where C_t is consumption, while:

$$GDP_t = C_t + I^G_t,$$

where I^G_t is gross investment in physical capital (e.g., gross fixed capital formation). Weitzman demonstrated that NDP can be interpreted as a long-run measure of economic well-being in that it is the stationary equivalent of future consumption. That is, the discounted sum of a hypothetical series of future consumption flows equal to current NDP equals the discounted sum of actual future consumption. He argued that a true measure of NDP should include, *inter alia*, the value of changes in resource stocks, a point echoed by Dasgupta and Heal (1979) and Solow (1986). That is, I^N_t in equation (4) should be defined as in equation (1).

Weitzman's result depends on two key assumptions.[4] The first is that a country's growth path is optimal. This assumption is, of course, routinely violated in the real world due to market and policy failures. The second is that social welfare equals consumption, as opposed to being a concave function of consumption. If this assumption does not hold, then NDP no longer equals the stationary equivalent of consumption (Dasgupta and Mäler 1995).

In response to the restrictiveness of these assumptions, Dasgupta and Mäler (1991, 1995), Mäler (1991), and Dasgupta, Kristöm, and Mäler (1996) proposed an alternative interpretation of NDP. They noted that NDP corresponds to a linear approximation of the Hamiltonian for a country's optimal growth problem. Hence, the change in NDP from one period to the next represents a first-order approximation of the change in long-run welfare during that interval, as long as the underlying changes in economic activities are relatively small and prices are not too distorted. This approximation holds even if a country is not currently on the optimal growth

[4] I thank Partha Dasgupta for drawing my attention to these assumptions.

path. A country can check whether its long-term welfare is rising, falling, or remaining constant by examining the change in NDP. If NDP is constant from one period to the next ($dNDP_t/dt=0$), the country did not increase its long-run welfare: the change in consumption was exactly offset by the change in net investment. An increase in long-run welfare is possible only if $dNDP_t/dt > 0$.

Performing the two sustainability tests requires the same basic information, i.e. estimates of I^N_t. In theory, the two tests are equivalent: NDP can rise only if the total capital stock increases, as NDP is precisely the return on the total capital stock (Solow 1986). In practice, however, they can give different results, due to measurement errors (e.g., unrecorded international capital flows) and the failure of investments to generate anticipated returns (hence, NDP_t can decrease despite I^N_t estimates being positive). We will see in the next section that such differences can be important in practice.

3 Application to Malaysia

Empirical efforts to implement the concepts discussed in section 2 have yielded plausible results. For example, one study estimated that, after accounting for depletion of natural resources, East Asia, the most rapidly growing region in the world, experienced positive net investment during 1962-91, while sub-Saharan Africa, where incomes have deteriorated more than in any other region, experienced negative net investment (World Bank 1995). That study and others, however, including well-known ones by the World Resources Institute in Indonesia and Costa Rica (Repetto et al. 1989, 1991) and a multi-country study by Pearce and Atkinson

(1993),[5] equated dR_t/dt to total resource rent instead of just Hotelling rent, as called for by equations (2) and (3). Hence, their results are biased away from sustainability, as total rent overstates the economic depreciation of natural resources.

The need for data on marginal extraction costs is the chief obstacle to direct application of equations (2) and (3). This study developed a method for estimating Hotelling rent in the absence of such data. The method involved first calculating total resource rent, and then converting it to Hotelling rent by using estimates of the elasticity of the marginal cost curve and the number of years remaining until resource stocks will be exhausted. This method is similar to one developed by El Serafy (1989), but it is derived by a different approach, and it involves less restrictive assumptions. We applied it to two categories of natural resources, minerals and timber. These are the commercially most important natural resources in Malaysia. The impacts on the analysis of ignoring other forms of natural capital will be discussed in the concluding section.

3.1 Hotelling rent estimates for minerals

Minerals and timber are heterogeneous resources in Malaysia, comprising dozens of distinct commodities (individual minerals and tree species) produced at hundreds of sites (mines and timber concessions). Resource quality and extraction costs vary across sites. Estimating dR_t/dt from data disaggregated by commodity, site, and quality class would be ideal, but such data are not available. Instead, a more aggregate approach must be used.

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[5]Other applied studies include Bartelmus et al. (1993), Devarajan and Weiner (1990), Landefeld and Hines (1985), Peskin (1989), Stauffer (1986), van Tongeren et al. (1993), and Ward (1982).

We first obtained data on value-added, salaries and wages, and value of fixed assets in mining and stone-quarrying industries from the Malaysian Department of Statistics' annual *Industrial Surveys*. The *Surveys* cover most but not all firms in the minerals sector. We converted the data to real terms using the GDP deflator (1978 price levels). We then subtracted salaries and wages from value-added to calculate the combined rents to physical capital and natural resources. In a competitive economy, payments to physical capital equal the product of the capital stock times the opportunity cost of capital. We set the former equal to the value of fixed assets in mining and stone-quarrying industries and the latter equal to the average rate of return on fixed assets in manufacturing industries, and we subtracted the resulting product from combined rents to obtain total resource rent. Finally, we scaled this survey-based estimate to the national level by multiplying it times the ratio of GDP in Sector 2 of the national income accounts, "Mining and Quarrying," to the aggregate value-added figure for the firms included in the *Surveys*. We allocated the resulting national estimate across regions in proportion to regional shares of GDP in Sector 2.

The formula for converting total rent to Hotelling rent was derived as follows. Suppose that the marginal cost of producing q_t tonnes of a nonrenewable resource in period t is given by $c'(q_t) = \alpha q_t^{\beta}$. The remaining stock of the resource at the beginning of period t is S_t, the price of a tonne of the extracted resource is constant over time at p, and the discount rate is i. Under an optimal extraction program, marginal cost equals average cost at the instant the stock is exhausted (the terminal-time transversality condition). The period when this occurs is T. For the marginal cost specification given above, average cost equals $c'(q_t)/(1+\beta)$, which can equal $c'(q_t)$ only if $q_t = 0$, as $c'(q_t)$ then equals zero as well. In turn, this implies that marginal rent in period T equals p. Then by Hotelling's Rule we have:

$$p = [p-c'(q_t)](1+i)^{T-t},$$

which after rearrangement yields:

$$c'(q_t) = p[1 - (1+i)^{t-T}]. \qquad (5)$$

The ratio of Hotelling rent (HR_t) to total resource rent (TR_t) equals the ratio of marginal rent to average rent, or:

$$HR_t/TR_t = [p-c'(q_t)] / [p-c'(q_t)/(1+\beta)].$$

Substituting equation (5) for $c'(q_t)$, this equals:

$$HR_t/TR_t = (1+\beta) / [1 + \beta(1+i)^{T-t}].$$

If we approximate the number of years until terminal time by S_t/q_t-1 (we subtract one because $q_T=S_T$), this becomes:

$$HR_t/TR_t = (1+\beta) / [1 + \beta(1+i)^{S(t)/q(t)-1}]. \qquad (6)$$

This equation equals 1 when the resource is exhausted, and it is less than 1 in preceding periods. It is the general form of the formula proposed by El Serafy (1989), which applies to the special case when β is infinite.

For the Malaysian application, i was set equal to 10 percent, which is between the estimates of the social discount rate for the 1970s (8 percent) and 1980s (13 percent) reported by Veitch (1986),[6] while β and $S(t)/q(t)$ were set equal to values for the petroleum subsector,

[6]A social discount rate of 10 percent is plausible in a fast-growing economy like Malaysia's. The social discount rate is the weighted average of the social rate of time preference and the marginal opportunity cost of capital. The former is given by the sum of the pure rate of time preference and the consumption discount rate, which is the product of the elasticity of marginal utility and the rate of change in consumption. Markandya and Pearce (1988) report estimates of 0-2 percent for the pure rate of time preference and 1-2 for the elasticity of marginal utility. Applying these to Malaysia, which had a per capita GDP

which accounted for most of the value-added in Sector 2 during the 1970-90 period. The value of β was 0.15, which is implied by the development cost function for Malaysian oil fields given in a report by the World Bank (1992b). That function relates total development cost (c_D) to the size of an oil field (Z):

$$c_D(Z) = 40 * Z^{0.85}.$$

This implies that the development cost of a marginal field is:

$$c_D'(Z) = 32 * Z^{-0.15}. \qquad (7)$$

Note that marginal development cost declines with field size. Assuming, as is likely, that the largest fields are discovered and developed first, this implies that increases in production are associated with rising marginal development costs. Operating costs do not vary with field size (World Bank 1992b), and so the overall marginal cost elasticity equals the marginal development cost elasticity:

$$\beta = -dc_D'(Z)/dZ * dZ/dq * q/c_D'(Z).$$

Substituting equation (7), and assuming that $q = Z/15$ (on average, 1/15th of the oil in a field is extracted each year; see World Bank 1992b), this yields a value of 0.15. $S(t)/q(t)$ was calculated by assuming that the stock of oil at the beginning of 1970 equaled 4.9 billion barrels, the estimated oil "originally-in-place" in Malaysia.

The resulting Hotelling rent/resource rent ratios for petroleum based on equation (6) are shown in Figure 2. The values in Figure 2 were used directly to convert total rents to Hotelling

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growth rate of 3.7 percent per year during 1970-90, yields an estimated social rate of time preference of 3.7-9.4 percent. The marginal opportunity cost of capital was surely far in excess of 10 percent during most of the period, making a weighted average of 10 percent or greater entirely possible.

rents in Sabah and Sarawak, where the minerals sector has been dominated by petroleum since the 1970's. For Peninsular Malaysia, where tin accounted for a significant share of mineral rents into the mid-1980s, values of the ratio before 1986 were set equal to 0.5, the assumed weighted average of the Hotelling rent shares for tin and oil. Table 1 shows the Hotelling rent estimates. Hotelling rents were highest in Peninsular Malaysia and lowest in Sabah in all years. They rose in all regions during the period, especially during the 1980s. This reflects both the rapid expansion in petroleum production and the rising share of Hotelling rents.

3.2 Hotelling rent estimates for timber

For timber, we first constructed for each region a set of physical accounts that gave annual estimates of forest areas and gross timber stocks (i.e., volume inclusive of defect). These accounts were based on both published data and data specially provided by the Forestry Departments in the three regions. They covered natural forests only,[7] and they were divided into sections on virgin (unlogged) and logged-over forests. They indicated, in an internally consistent way, aggregate increases in timber stocks due to growth, and aggregate decreases due to four factors: net harvest, logging damage and defect, deforestation, and miscellaneous adjustments necessary to balance the accounts. Table 2 shows aggregate national estimates of these components for the 1970-90 period. Note that net harvest accounted for only about a quarter of the gross reduction in timber stocks. This suggests that the country lost significant potential rents from timber production.[8] Vincent, Rozali, and Associates (in review) provide

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[7] Significant areas of timber plantations were established in Malaysia only recently.

[8] Some of the timber volume included in the "Miscellaneous adjustments" row in Table 2 could represent illegal logging. In that case, the country is not losing rents. The rents are simply being captured entirely by the illegal loggers.

more details on the physical accounts.

Most logging during 1970-90 occurred in virgin forests. In this situation, it turns out that the economic depreciation of timber resources can be estimated using the same method as for minerals. That is, one can apply equation (6). The validity of this approach can be demonstrated as follows. Denote harvests from virgin (primary) forests by q^P and harvests from logged-over (secondary) forests by q^S. Time subscripts are suppressed to economize on notation. Under sustained-yield management of logged-over forests, which is the policy in Malaysia, harvest equals growth: $q^S = g(A)$, where A is the area of logged-over forest. The change in area of logged-over forest is given by $(1-d)q^P/v$, where d is the deforestation rate and v is the per-hectare harvest in the virgin forest. This formulation assumes that deforestation occurs only in virgin forests, immediately after they are logged.

Under these assumptions, the current-value Hamiltonian for optimal forest harvesting (maximization of the discounted sum of resource rents) is given by:

$$\mathcal{H} = p(q^P + g(A)) - c^P(q^P) - c^S(g(A)) - \lambda^P q^P + \lambda^A(1-d)q^P/v,$$

where c is a logging cost function and λ is an adjoint variable. The net economic depreciation of the forest equals the sum of the last two terms. There is just one control variable, the harvest in the virgin forest, q^P. The first-order condition for this variable is:

$$\lambda^P = p - c^{P\prime} + \lambda^A(1-d)/v.$$

This relation enables us to rewrite the Hamiltonian without the adjoint variable for area of logged-over forest:

$$\mathcal{H} = p(q^P + g(A)) - c^P(q^P) - c^S(g(A)) - (p-c^{P\prime})q^P.$$

Economic depreciation is now given by just the last term, $(p-c^{P\prime})q^P$, which is marginal stumpage value times harvest in the virgin forest.

This term can be estimated by applying equation (6) to total rent from the virgin forest only if marginal stumpage value approximately obeys Hotelling's Rule. The adjoint equations for the timber stock in virgin forests and the area of secondary forest are, respectively:

$$d\lambda^P/dt = i[(p-c^{P\prime}) + \lambda^A(1-d)/v]$$

$$d\lambda^A/dt = i\lambda^A - g'(p - c^{S\prime}).$$

If g' varies little with area (a standard assumption in forest planning models in Malaysia) and $c^{S\prime}$ varies little with harvest (empirical evidence does not reject this assumption), then integrating the second equation yields $\lambda^A = g'(p - c^{S\prime})/i$. That is, the value of a unit area of logged-over forest is given by an annuity involving the timber growth rate and marginal rent. Substituting this into the first adjoint equation yields:

$$d\lambda^P/dt = i[(p-c^{P\prime}) + (1-d)g'(p - c^{S\prime})/i/v].$$

The marginal stumpage value in virgin forests approximately obeys Hotelling's Rule as long as the second term in the bracket is small relative to the first. This is likely in Malaysia. For example, mean values in the physical accounts for Peninsular Malaysia during 1970-90 were $d = 0.40$, $g' = 2.2$ m^3/ha/yr, and $v = 114$ m^3/ha. If $i = 10$ percent, then the value of the second term is just $0.12(p-c^{S\prime})$. Hence, the second term is small relative to the first as long as the marginal stumpage value in logged-over forests $(p-c^{S\prime})$ is not substantially larger than the marginal stumpage value in virgin forests $(p-c^{P\prime})$. This is the usual case in forestlands around the world.

We therefore estimated the Hotelling rent for timber by multiplying the total resource rent associated with the virgin harvest times the ratio given by equation (6). We calculated the former by multiplying average stumpage value (log price minus average logging cost) times the sum of virgin harvest plus timber volume lost to deforestation. We included timber volume lost to deforestation because it represents the loss of commercially valuable timber, and we excluded timber defect and logging damage on the assumption that defect and damage are unavoidable.[9] In applying equation (6), we assumed a marginal cost elasticity of 3, based on Vincent (1990).

Table 3 shows the estimated Hotelling rents on an annual basis. At the national level, Hotelling rents rose until 1979-80 but declined thereafter, although not to levels as low as in the early 1970s. This pattern mirrors changes in stumpage values, which peaked in 1979-80 during the global commodity price boom. The decline in stumpage values in the 1980s offset the effects of rising harvests and a rising Hotelling rent share. Hotelling rents for timber were generally greater than for minerals before the mid-1980s, but by 1990 they were only a third as large. At the subnational level, Hotelling rents were generally lowest in Sarawak, due to low stumpage values in that state.

3.3 Estimates of net investment and NDP

Figure 3 shows per capita estimates of net investment. These were calculated by subtracting depreciation of physical capital and Hotelling rents for minerals and timber (from

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[9]The following model is simpler than the one presented in the text, but it serves to make the point. Suppose that a country has a stock, S_t, of a nonrenewable resource. The amount extracted is given by q_t. For every unit extracted, an additional f units are unavoidably lost. Total extraction costs are $c(q_t)$, and a unit of the resource sells for p. The current-value Hamiltonian is:

$$\mathcal{H} = pq_t - c(q_t) - \lambda_t(1+f)q_t.$$

If q_t is chosen optimally, then λ_t equals marginal rent divided by one plus the damage rate:

$$\lambda_t = (p_t - c'(q_t))/(1+f).$$

Hence, economic depreciation (the last term in the Hamiltonian) equals just $-(p-c'(q_t))q_t$: it does not include unavoidable production losses.

Tables 1 and 3) from gross fixed capital formation (from the national income accounts). The estimates of depreciation of physical capital were extrapolated from data in the Malaysian Department of Statistics' annual *Report of the Financial Survey of Limited Companies*.[10] The estimates of net investment are partial ones, as they omit changes in human capital (dH_i/dt in equation (1)). We will return to this point, which is an important shortcoming of the analysis, in the concluding section.

At the national level, per capita net investment was positive in all years but one. Hence, per capita total capital stocks increased in Malaysia during the 1970s and 1980s, despite the depletion of the country's mineral and timber resources. On this basis, per capita consumption levels appear to have been more than sustainable. The country did better than Hartwick's Rule.

This was not the case in all three regions. Per capita net investment was positive in Peninsular Malaysia in all years, but it was negative in every year after 1975 in Sabah and in every year but one after 1983 in Sarawak. The two Borneo states depleted their natural capital more rapidly than they built up stocks of physical capital in the 1980s, with the net reduction in the total capital stock being particularly large in Sabah. Consumption levels became more sustainable over time in Peninsular Malaysia, but less sustainable in Sabah and Sarawak.

Analysis of trends in NDP provides a check on this conclusion. If net investment was truly positive in Peninsular Malaysia and for the country as a whole, then per capita NDP should have risen. If this was not the case, then the estimates of per capita net investment in Figure 3 are probably biased upward. This could occur, for example, if not all investments were in fact

[10]The definition of depreciation used in the *Financial Survey* is based on the tax code, which allows rates of depreciation that are probably more accelerated than actual rates. Hence, our estimates of depreciation of physical capital are probably biased upward.

productive ones.

Figure 4 shows annual estimates of per capita NDP. The latter was calculated analogously to net investment: depreciation of physical capital and Hotelling rents for minerals and timber depreciation were subtracted from GDP. At the national level, results are as expected: per capita NDP rose along with per capita GDP in most years. Hence, the economy apparently grew in a sustainable fashion. The average annual growth rate for per capita NDP was considerably less than for per capita GDP, however: 2.9 percent compared to 3.7 percent. True income grew, but not nearly as rapidly as GDP.

Results for Peninsular Malaysia were also consistent with the net investment results. Per capita NDP rose in most years, although the rate of increase was again less rapid than for per capita GDP, 3.2 percent per year vs. 3.8 percent per year. The discrepancy is less than for Malaysia as a whole, which is not surprising given that Peninsular Malaysia was less resource-dependent than the Borneo states (the effects of resource depletion were diluted). Per capita NDP in 1990 was nearly double the level in 1970, RM 3594 vs. RM 1799.

Per capita NDP grew much more slowly in Sabah and Sarawak: 1.6 percent per year in Sabah and 1.4 percent per year in Sarawak. Both rates were much smaller than the corresponding growth rates for per capita GDP, 2.9 percent and 3.4 percent, respectively. The positive NDP growth rate for Sabah would appear to contradict the finding of negative net investment. This apparent contradiction might reflect a downward bias in the estimates of conventional net investment, due to incomplete data on gross fixed capital formation. Pang (1993) has criticized official Malaysian investment data for excluding certain types of agricultural investments, which are relatively more important in the Borneo states than in the more industrialized Peninsula. Examined more closely, however, the positive growth rate is not very reassuring. Per capita NDP fell in many years, often by substantial amounts. Although it recovered during the late 1980s from a substantial decline during the 1970s, it was not much higher at the end of the period than at the beginning: it averaged RM 2119 during 1985-90 compared to RM 1720 during 1970-75.

The results are more consistent for Sarawak, but no more reassuring. Per capita NDP rose, in fits and starts, up to 1984, but it declined thereafter. The decline coincides with the switch from positive to negative values of per capita net investment shown in Figure 3. At the end of the period, per capita NDP had dropped to levels typical of the mid-1970s, around RM 2200.

In sum, the three regions began the 1970s at nearly identical levels of per capita NDP, but by 1990 the Borneo states had fallen far behind the Peninsula. Although all three achieved high rates of GDP growth, only the Peninsula increased its sustainable consumption level significantly.

4 Conclusions

Resource-rich countries can sustain their consumption levels only if they accumulate stocks of reproducible capital at a rate that at least matches the economic depreciation of natural capital. Analyses of both net investment and NDP indicate that, at the national level anyway, Malaysia succeeded in doing this during the 1970s and 1980s. Both analyses indicate that economic prospects differ within the country, however, with prospects being much dimmer for the Borneo states than for Peninsular Malaysia. Only the analysis of per capita NDP offers much evidence that consumption levels can be sustained in the Borneo states, and that evidence indicates that the consumption levels that can be sustained are the ones that the states experienced twenty years ago, not the ones they are enjoying today.

The lesson for other resource-rich developing countries is to emulate Peninsular Malaysia's example, by adopting economic policies that result effectively in the reinvestment of a substantial portion of resource rents. Sabah and Sarawak have instead grown by simply raising their natural resource output and consuming much of the rents thus generated. This is not a sustainable development strategy.

Several features of the analysis should be borne in mind in evaluating these conclusions. Three suggest that Malaysia's performance was even better than the results indicate. One is the incompleteness of gross investment data noted by Pang (1993). The second is that the analysis implicitly focused on the sustainability of domestic economic activity, by using gross fixed capital formation as the measure of investment and GDP (as opposed to GNP) as the measure of income. This ignores the fact that overseas investments and employment can make important contributions to the financing of national consumption. The third and probably most important feature is the omission of changes in the country's human capital stock, which was certainly much greater in 1990 than in 1970. The percentage of Malaysians of school age enrolled in secondary education rose from 28 percent in 1965 to 59 percent in 1989, and the adult illiteracy rate fell to 22 percent by 1990, better than average for lower-income countries (World Bank 1992a).

Three other features create a bias in the opposite direction, however. The first is that the analysis implicitly treated production levels of minerals and timber as optimal. If resources were not managed optimally, then the long-term increases in consumption that Malaysia apparently achieved were not as large as they could have been.[11] The second is that the analysis ignored depletion of all natural resources other than minerals and timber. For this reason, it surely understated the depletion of natural capital. The third is that the analysis ignored direct consumption values of the environment. To the extent that economic growth in Malaysia reduced these values, as indeed it did due to rising air and water pollution and diminishing amenity values, the estimates of NDP were biased upward. Hence, the increases in NDP in Figure 4 overstate the actual increases in welfare generated by economic growth.

The net impact of these six factors on the pessimistic findings for Sabah and Sarawak is unclear. But to be on the safe side, policymakers in the two states ought to consider ways of increasing public and private investment levels. Paraphrasing Solow (1992), the problem the states face is not depletion of natural resources, but overconsumption of resource rents. Unfortunately, increasing investment is likely to be difficult, as neither state is an intrinsically attractive location for investors. Both are in remote locations, have small populations, and have terrain that makes infrastructure development especially costly. Nothing in economic theory suggests that it is efficient to sustain economic activity in all locations. Historically, outmigration has followed resource depletion in resource-based economies in many regions of the world. This process is socially disruptive, but it might be inevitable and in fact economically efficient when resource-extractive industries are the only viable ones in a region. This could well be the case in Sabah and Sarawak. Resource rents generated in the two states might be better invested in Peninsular Malaysia and abroad. Although Malaysia's development appears

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[11]The study by Devarajan and Weiner (1990) is apparently the only empirical study to make adjustments for suboptimal resource depletion.

to be sustainable at the national level, it might not be so in all subnational regions.

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Table 1. Hotelling rents for minerals.

Year	Malaysia	Peninsula	Sabah	Sarawak
		Million RM (1978 prices)		
1970	387	387	0	0
1971	398	398	0	0
1972	453	453	0	0
1973	381	381	0	0
1974	594	594	0	0
1975	176	176	0	0
1976	455	455	0	1
1977	333	332	0	1
1978	364	357	2	4
1979	416	383	12	21
1980	654	598	23	32
1981	850	788	25	37
1982	1000	850	58	92
1983	1384	986	147	252
1984	1785	1102	241	442
1985	1954	1162	267	525
1986	2082	1138	324	620
1987	2252	1234	356	662
1988	2475	1360	397	718
1989	3038	1673	495	870
1990	3788	2092	626	1070

Table 2. Aggregate changes in gross timber stocks in Malaysia during 1970-90.

Component	Quantity
	1000 m^3
Additions to timber stocks:	
Growth	318,641
Subtractions from timber stocks:	
Harvest	598,499
Logging damage and defect	594,977
Deforestation	656,291
Miscellaneous adjustments	631,930
Net change	-2,163,056

Table 3. Hotelling rents for timber.

Year	Malaysia	Peninsula	Sabah	Sarawak
		Million RM, 1978 prices		
1970	163	29	131	2
1971	215	45	166	3
1972	332	126	202	3
1973	829	224	594	10
1974	630	95	531	4
1975	321	75	244	1
1976	1114	199	891	24
1977	1133	225	895	13
1978	1073	250	812	10
1979	2249	466	1739	44
1980	1862	488	1335	38
1981	1972	435	1511	26
1982	2076	191	1829	56
1983	1695	308	1355	32
1984	1489	160	1255	74
1985	1033	90	898	45
1986	1105	161	903	41
1987	1450	255	1118	77
1988	1407	352	979	76
1989	1602	644	762	197
1990	1361	647	514	200

Figure 1
Components of resource rent

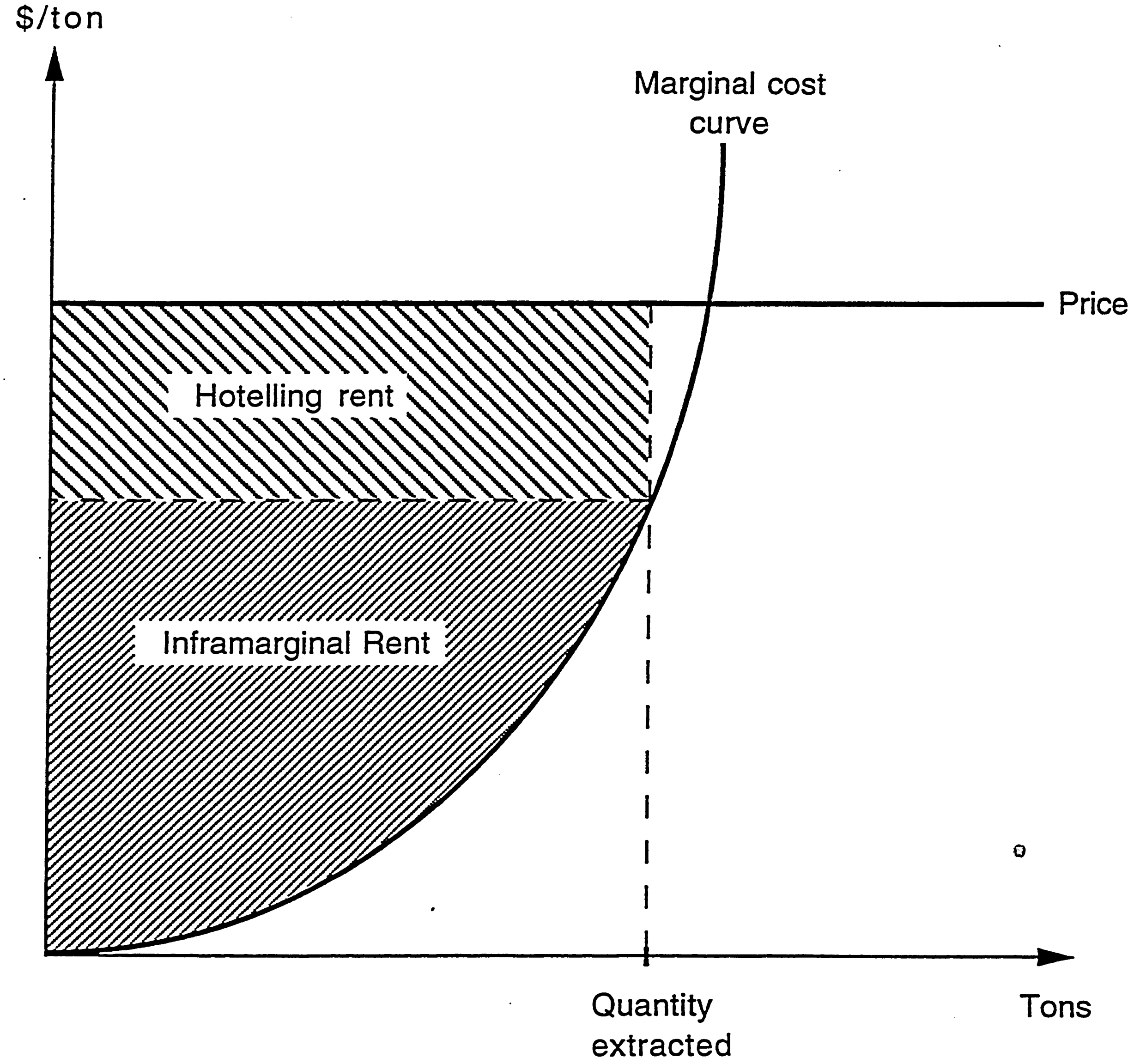

Figure 2. Ratio of Hotelling rent to total resource rent for oil

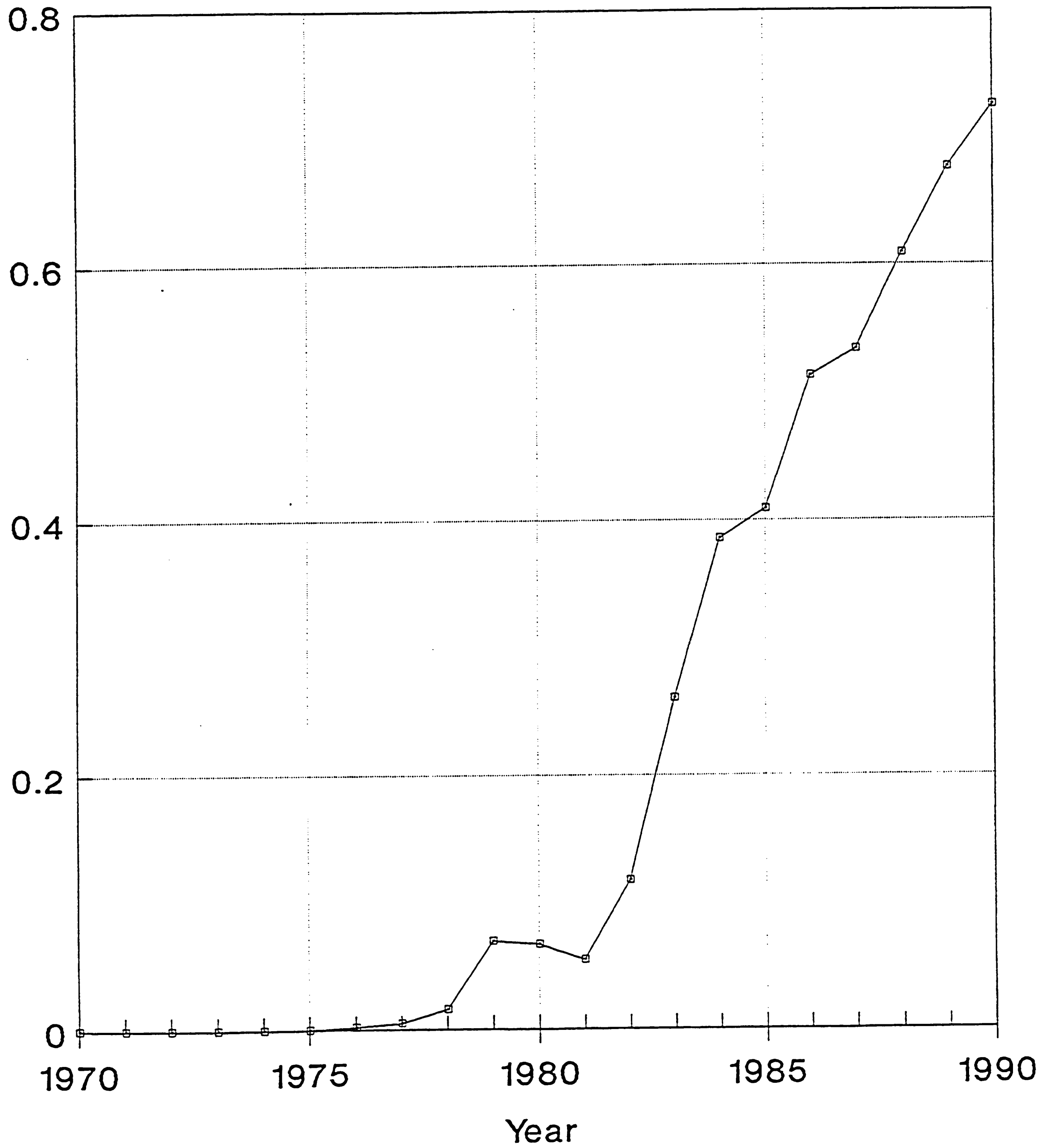

Figure 3. Per capita net investment

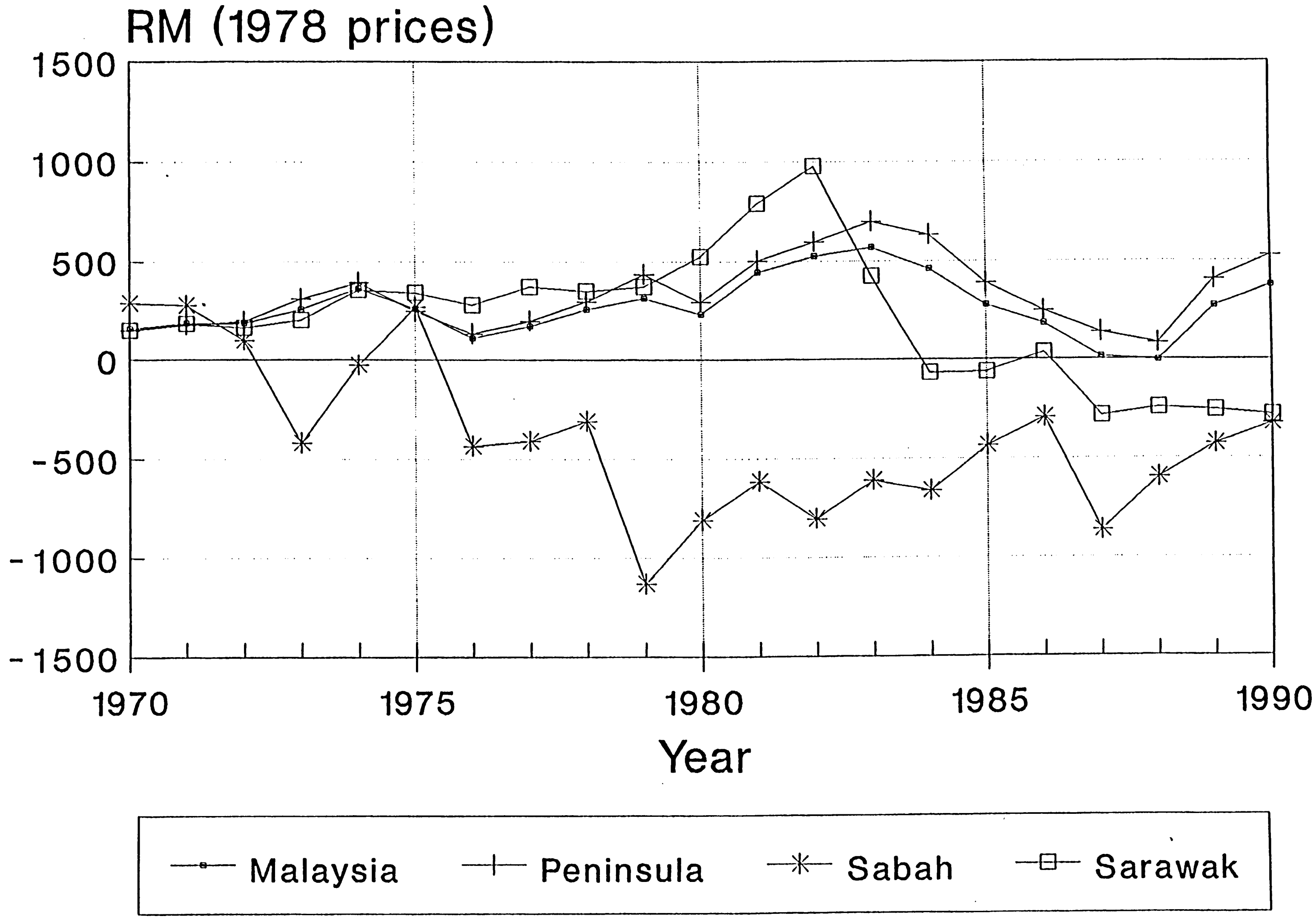

Figure 4. Per capita NDP