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Development strategy and trade liberalization: implications for poverty and environment in the Philippines

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ABSTRACT. Poverty and environmental degradation or deforestation in developing countries have common determinants in underlying economic and institutional conditions that determine factor and product prices and incentives for migration and resource-depleting activities. These determinants include property rights failures (open access to forest lands) but also 'government failures' in the form of policies that indirectly promote resource use and retard poverty alleviation. A general equilibrium analysis identifies influences that such distortions have on poverty and environment. Using a numerical GE model, we consider likely effects of Philippine trade policy reforms of the 1990s on determinants of poverty, deforestation, and agricultural land expansion. These reforms marked a significant shift away from the import substitution industrialization strategy that characterized post-independence Philippine development. The results suggest that though reforms would increase poverty in the short term, in the longer run trade liberalization is poverty reducing. The environmental impact can also be positive, provided liberalized trade is combined with appropriate government action to address market failures.

1. Introduction

The period from about 1980 to 1997 marked a critical economic and environmental transition for the Philippines. By the beginning of this

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era, years of rapid population growth coupled with low non-agricultural employment increase had generated high and persistent poverty, especially in rural areas. For very many of the poor, the solution to poverty and joblessness was to colonize land from forest at the cultivated frontier, a strategy made relatively attractive both by the activities of commercial logging operations and by the absence of meaningful property rights in forests or forested land. During this period, commercial logging, once a mainstay of rural employment and export revenues, diminished to very low levels as commercially viable opportunities for timber extraction receded with forest area, and land conversion for agriculture – itself increasingly commercialized – became the dominant source of deforestation pressures.

Toward the end of this period the Philippines began to take its first serious steps away from the import-substituting industrialization (ISI) strategy it had pursued since the 1950s and to dismantle its structure of protectionist trade barriers. After a few years of partial and piecemeal liberalization in the 1980s, a comprehensive 1991–1995 reform package (known by its legislative name as Executive Order (EO) 470 mandated wide-ranging change to a highly distortionary and sectorally discriminatory trade policy regime.

The economic effects of trade liberalization in an open economy can be expected to be large, due to the pervasive effects of trade barriers on resource allocation, factor incomes, and government finances. Such reforms alter income distribution and poverty through changes in household incomes and consumer prices; they also have direct effects on incentives to exploit natural resource endowments, including forests, land, and water. Furthermore, changes in poverty and in the natural resource base may also interact in a variety of ways.

In this paper we examine the likely effects of the EO470 trade policy reform on poverty and the demand for agricultural land. These are seen to augment, indirectly, more direct incentives for deforestation operating through the price mechanism. The reforms generate economy-wide adjustments in product and factor markets, consumer incomes and expenditures, and government revenues and expenditures caused by trade policy changes, and so clearly a general equilibrium approach is required. Much of the paper is devoted to the presentation of an applied general equilibrium model of the Philippine economy; its use to simulate the effects of the EO470 reform, and discussion of the economic, environmental, and policy implications of the results; but the findings have more general implications for developing countries undertaking policy reforms.

Our findings, under plausible assumptions about the operation of key markets such as that for unskilled labor, are that the trade reform package of the early 1990s reduced deforestation and land degradation pressures, and also reduced poverty. These findings are consistent with trends in Philippine data on poverty, deforestation, and agricultural land use during the period. The analysis further suggests that the effects of the trade reform package depend not only on the reduction of average levels of protection, but also on how the structure of relative protection is changed. EO470 and also subsequent Philippine trade reforms have tended to increase agricultural tariffs in relative and even absolute terms, even as they reduce protection across the board. This observation leads us to some conclusions about the

hidden environmental costs of a partial trade policy reform strategy that, in effect, exempted key agricultural sectors.

2. Pressures on forest and land resources

Forests

The forest and upland ecosystem of the Philippines covers around 45 per cent of total land area, and its resources directly support about 30 per cent of the population, including some of the poorest in the country. It is experiencing severe pressure of a variety of kinds, the most prominent of which is the conversion of forest for agriculture.

The Philippines has consistently had the highest deforestation rate in Southeast Asia, and one of the highest among all developing countries. During the twentieth century national forest cover fell from more than 75 per cent of land area to about 60 per cent by 1950, about 25 per cent by 1980, and about 18 per cent by the late 1990s. Within Southeast Asia, the deforestation rate from 1980 to 1990 (3.3 per cent) was matched only in Thailand; in the subsequent decade, the Philippine rate fell to about 1.4 per cent, but that in Thailand fell twice as fast, to 0.7 per cent (Coxhead and Jayasuriya, 2003b).

The two main causes of deforestation are land clearance for agriculture and commercial exploitation of forests for logs, lumber, fuel (including charcoal), and pulpwood. Historically, commercial logging (both legal and illegal) has been the primary force behind depletion of old-growth forests, with conversion to agricultural uses accounting for much of the deforestation of degraded, secondary, or residual forest lands.

In the past two decades, however, the commercial timber industry has diminished greatly in importance along with the loss of primary forest cover. Gross value added in forestry and wood products fell in absolute terms throughout the 1970s and 1980s; as a result the GDP share of timber industries fell from 2.5 per cent in 1975 to only 0.3 per cent in 1994. Whereas timber and processed wood products were major sources of foreign exchange, accounting for as much as one-third of all exports during the late 1960s, they now add to only 0.2 per cent of export receipts (or 1.15 per cent if the gross value of finished wood products is included) (NSCB, 1995). The Philippines is now a net importer of timber.

Agriculture and croplands

Agriculture remains the single largest sector and employer in the Philippine economy; well over half the population depends either directly or indirectly on income generated through agricultural production (David, 2003). Land scarcity is a major constraint to continued agricultural growth; although investments in irrigation and episodes of technical progress have increased yields of some crops (notably irrigated rice), Philippine agriculture has experienced relatively low overall rates of productivity growth, and average cereal and root crop yields and rates of fertilizer use are among the lowest in tropical Asia (WRI, 2001). In unirrigated uplands, increases in agricultural production have been obtained through expansion at the cultivated margin

Table 1. *Erosion rates by land use: Philippines*

Land use	*Erosion rates (t/ha/yr)*
Undisturbed forest	0.1–0.4
Second growth forests	1–7
Rice paddies	0.2–10
Plantations (dep. on age and species)	2.4–75
Grasslands	1.5–3
Overgrazed lands	90–270
Shifting cultivation (no conservation measures)	90–240
Annual cash crops (uplands)	30–180

Source of basic data: ENRAP (1994).

rather than through improvements in the efficiency with which existing land resources are utilized. Between 1960 and 1987, the upland population more than doubled to an estimated 18 million, and the area devoted to upland agriculture increased six-fold, coinciding with a rapid decline in forest cover (Bee, 1987; World Bank, 1989; Cruz *et al*., 1992).

Whereas expansion of agricultural land area was almost certainly an appropriate agricultural development strategy in earlier decades when land was abundant, in the final quarter of the twentieth century the conversion of forests and upper watershed areas to agriculture (and especially to production of annual crops) became a significant source of environmental problems. A large proportion of the uplands have steep slopes which, once cleared of permanent vegetative cover, are prone to severe land degradation, particularly soil erosion. Shifting cultivation (*kaingin*) systems traditionally practiced by indigenous upland communities were environmentally sustainable in the past, but increased population pressure in uplands has reduced fallow periods, and the more intensive farming practices of new immigrants to uplands are more land degrading (table 1; and see David, 1988; Cruz *et al*., 1988). Recent estimates suggest that between 74 and 81 million tons of soil are lost annually through erosion from upland farm lands, and that between 63 per cent and 77 per cent of the country's total land area is affected by erosion (FMB, 1998).[1]

Recent evidence on long-term trends in the productivity of lowland agricultural areas is equally disturbing, in large part because the productivity of lowland crop land is directly dependent on the quality of irrigation services provided by surface water resources. Deforestation and upland agricultural expansion has accelerated the degradation of watersheds and hydrological systems, clearly diminishing the quality of irrigation services in many parts of the country. Annual stream flow fluctuations are exaggerated in watersheds where water retention capacity

[1] See, for example, World Bank (1989). By 1993, 17 per cent of the total land area was estimated to be badly eroded, 28 per cent moderately eroded, and a further 29 per cent slightly eroded (Republic of the Philippines, 1998). In this source the annual cost of on-site damage from erosion *only* was estimated to be about 0.25 per cent of GDP.

has been lost along with forest cover and biomass, making such systems more prone to the effects of drought and flash flooding.[2] Soil runoff raises the total suspended sediment (TSS) loadings of rivers and increases silt deposition rates in dams and canals. Sedimentation has significantly reduced storage capacity in all of the Philippines' major reservoirs, and has measurably affected domestic water consumption, power generation, and irrigation. In areas where commercial agricultural production is pursued intensively, pesticide runoff is also a problem (Deutsch *et al*., 2001).[3] Over the last 25 years, dry season irrigated area has fallen by 20–30 per cent in several of the country's key irrigation systems (FMB, 1998).

The decline of agricultural land productivity throws some aspects of Philippine agricultural and economic development policy into sharp relief. With the upland frontier virtually closed and emerging signs of productivity growth slowdown – or even reversal – in the 'best' lowland irrigated areas, the degradation of the agricultural land base is a source of serious policy concern in its own right. Continued land degradation is a major problem if the dependence of the rural population on agricultural incomes remains high due to low labor demand in non-agricultural sectors; upland land degradation reduces the earning power of the poorest section of the Philippine population. Moreover, the highest fraction of upland land is planted to corn, which is a highly erosive crop in sloping lands under conventional land management practices in the Philippines.[4] Agricultural development strategies predicated on self-sufficiency in cereals have been influential in promoting corn area expansion in uplands, and thus in contributing to ongoing land degradation (Coxhead, 1997, 2000).

3. Development policies and poverty outcomes

Development policies

The development strategy pursued by the Philippines from the early post-independence period was based on import-substituting industrialization. In this respect the Philippines was not very different from many other developing countries. But, unlike many of its neighbors in East and

[2] Time series data on this topic are still scarce, but see Deutsch *et al*. (2001) for a Philippine example.

[3] The downstream effects of deforestation and watershed degradation are not the only sources of environmental concern in Philippine agriculture. In cereal crops, production growth has been associated with increasingly intensive use of inorganic fertilizers and pesticides, in spite of the introduction of 'environment-friendly' techniques such as integrated pest management (IPM). Health and other problems associated with chemical use in rice production have been documented by Rola and Pingali (1993).

[4] Smaller areas of upland are planted to upland rice, vegetables, tree crops, and pasture. Although the national planted area of major cereals such as corn has declined somewhat since about 1990, this is due more to the conversion of lowland acreage to other crops and to non-agricultural uses than to a contraction at the land frontier.

Southeast Asia, it failed to make an early transition to an export-oriented strategy. Significant trade reforms were initiated only in the late 1980s, and the country really started to shake free of its strong protectionist regime only in the 1990s.[5] Industrial growth behind protective trade barriers discriminated against the labor-intensive export-oriented activities in which the Philippines enjoyed comparative advantage; the structure of effective protection was such that industries that were the least internationally competitive were the most sheltered from import competition. Not surprisingly, following the early phase of 'easy' import-substituting industrialization, manufacturing sector growth slowed, in spite of continuing large net transfers from other sectors, principally export agriculture.[6]

A second target of development policy was agricultural development – or more accurately, growth of cereal production. Imports of rice and corn, the principal food crops, were heavily regulated in pursuit of 'food security' – in practice defined as self-sufficiency with stabilized prices (Coxhead, 2000). The state retained monopoly control over international trade in these products and their substitutes, and its practices meant that domestic prices of rice and corn were determined substantially independently of international prices.[7]

Though cereals benefited from some forms of intervention, the overall impact of the policy regime on the agriculture sector was strongly negative (Intal and Power, 1990). This bias began to diminish in the late 1980s. Corn producers in particular gained increasingly from trade policy trends, with the effective protective rate for this crop rising from near zero in the late 1960s to above 70 per cent in the early 1990s and more than 90 per cent by the decade's end (Pagaluyan, 1998; David, 2003). Since corn is grown very widely in uplands (with upland rice, it accounted for about 45 per cent of cultivated land on slopes of above 18 per cent in the late 1980s), increased protection had a direct and negative environmental impact through expanded and intensified use of upland land.

Forestry policy has also been influential. First, early government programs, including state-sponsored settlement schemes, encouraged the conversion of forests to agricultural land.[8] Second, the state did not always enforce regulations limiting forest conversion, and this was the case not only with respect to activities of large commercial interests but also those of small farmers, often new immigrants to uplands. Third, there was both legal and illegal timber removal, with logging concessions being disbursed as part

[5] For early discussions of the trade policy in the Philippines, see Baldwin (1975) and Bautista, Power and Associates (1979). For the 1980s and 1990s see Tan (1995), and Bautista and Tecson (2003). The following discussion draws on Bautista and Tecson's analysis of the impact of trade reforms on industry structure and growth.

[6] See Baldwin (2002) for an excellent survey of the literature on 'openness' and economic growth.

[7] Cereals, principally lowland irrigated rice, also benefited from publicly funded irrigation investments and research and extension programs, as well as subsidies on fertilizer and agricultural chemicals.

[8] See Paderanga (1986) for an historical review of land settlement policies in the Philippines.

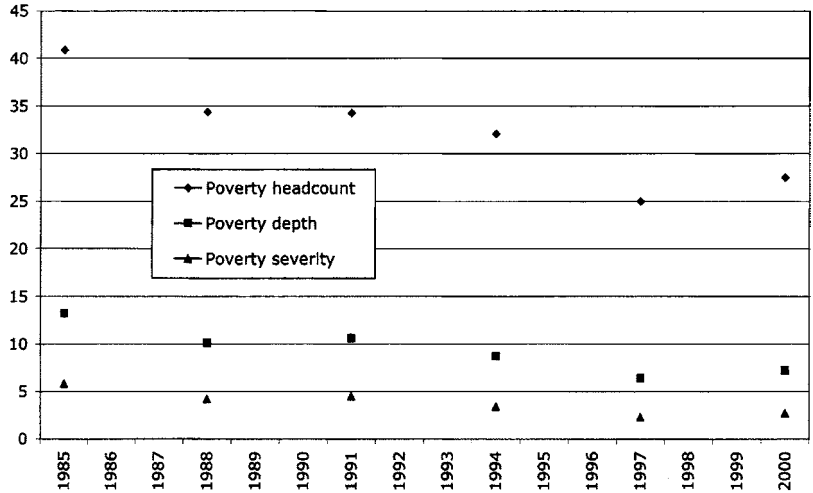

Figure 1. *Philippine poverty trends in the 1980s and 1990s (per cent)*
Source: Balisacan (2003, table 10.1)

of patronage politics to politically powerful groups, and a considerable proportion of 'illegal' logging being carried out with the sanction and often the complicity of government officials at all levels (Kummer, 1992). In practice, both legal and illegal logging facilitated land conversion to agriculture and hence played a critical role in this process, even though selective logging, in principle, need not cause deforestation.

It is clear that deforestation and associated agricultural land degradation problems in the Philippines cannot be attributed to population growth and/or 'market forces' alone. Development strategy and the institutional and legal context have been very important. It follows that environmental outcomes depend not only on direct environment-specific policy measures, but also on the indirect impacts of many other policies as well as exogenous developments in the economy. Many legislative and policy changes, even when they do not specifically target environmental variables, can have potentially large environmental effects.

Poverty trends and proximate causes

Poverty incidence in the Philippines has remained high by the standards of comparable countries. In 1985, 41 per cent of the population was classed as having income lower than the poverty line, a figure which fell to 34 per cent by 1991 and to 27.5 per cent by 2000 (Balisacan, 2003). Poverty is overwhelmingly a rural phenomenon, and the agricultural labor force (40 per cent of the total), makes a highly disproportionate contribution to poverty, about 65 per cent (ibid.). The poverty decline has not taken place at a constant rate, however; rather, poverty has fallen during periods of relatively rapid growth of the aggregate economy (1985–1988 and 1994–1997), and risen during periods of recession or stagnation (1988–1991 and 1997–2000; see figure 1). As Balisacan's study shows, these trends are robust even when controlling for the relatively slight changes in the distribution of

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income during these periods. The largest reduction in poverty, from 32 per cent to 25 per cent, came during the second half of the Ramos administration in 1994–1997, the period following implementation of the trade reforms that are the subject of this study.

In spite of large differences, the biggest disparities in human welfare in the Philippines occur within rather than between groups. Within rural areas, the poor are found disproportionately in uplands.[9] Upland populations depend more heavily on agriculture, a notoriously unstable source of income in developing countries, and on a natural resource base in which there has been, in relative terms, very little investment. The primary determinants of poverty among rural populations are thus easy to find. They are a lack of productive complementary resources, low human capital, risk-averse behavior in the face of yield and price instability, lack of opportunities for income diversification due to transport and other transaction costs, and thus low returns on labor and investments.

Spatial dimensions of poverty and environmental problems

The Philippines is geographically diverse, and poverty, growth, and development are strongly spatially differentiated. The three major island groups (Luzon, Visayas, and Mindanao) differ markedly in key demographic and socio-economic characteristics as well as in climate, topography, terrain, and other bio-physical attributes that influence natural resource endowments, including mineral deposits, land types, and crop productivity.

Urban–rural contrasts are also stark. In the post-war era there has been a geographic bifurcation of population growth rates. With few new employment opportunities in traditional, lowland-based agriculture and rural industry, and a high rate of natural increase, Philippine population growth has been greatest in urban centers and at the cultivated frontier. Philippine urbanization, and especially the growth of Manila relative to other urban centers, was in part a consequence of the ISI strategy.[10] By 2000, almost 60 per cent of the population lived in urban areas, of which one-third were in Metro Manila. Manila produces one-third of the country's GDP, and, in general, average family incomes in urban areas are more than twice as high as in rural areas.

As previously noted, another 30 per cent of the population lives in upland agricultural areas, most of them poor, capital-scarce migrants in

[9] Statistical estimates in Balisacan (2003) show the most significant correlates of poverty in Philippine provinces (sign of correlation in parentheses) to be landlocked (+), irrigation (−), typhoon-prone (+), agricultural terms of trade (−), and roads as a proxy for infrastructure (−). With the exception of typhoon-prone, upland areas normally score higher on all of the positive correlates and lower on the negative correlates.

[10] This does not imply that ISI policies alone are responsible for the urban bias in Philippine industrialization, particularly the Metro Manila bias. While ISI policies clearly contributed to this phenomenon, powerful economic forces of agglomeration tend to generate an urban bias in growth, and that would have occurred even under a more open trade regime (see Fujita, Krugman and Venables, 1999).

search of productive land. Starting in the 1950s, migrants from depressed rural areas created a boom in upland populations (Cruz and Francisco, 1993), accounting for a much greater share of upland population growth than did natural increase among existing populations. Land colonization, deforestation, and agricultural intensification on sloping and marginally arable lands ensued.

Within rural areas, population density and general indicators of household welfare are correlated with land quality, with irrigated lowlands supporting the wealthiest rural populations. Irrigated lowland rice cultivation is concentrated in the Manila hinterland as well as smaller areas in northern Luzon, the western Visayas, and southern Mindanao. The largest numbers of the rural poor are found in other parts of Mindanao and in the resource-poor, typhoon-prone eastern Visayas.

4. A general equilibrium approach

Economy-wide analysis with a multisectoral model

In open developing countries, trade policy is unusual among microeconomic interventions in that its effects are both profound and pervasive in the economy, affecting both aggregate growth and the structure of production and demand. Thus it may be hypothesized that trade and trade policies (or their reform) have major effects on environmental quality and natural resource depletion. There are a number of normative analytical explorations of this question (Copeland, 1994; Corden, 1997; Ulph, 1999), all of which focus on the general equilibrium welfare effects of trade policies in the presence of environmental externalities. By extrapolation, these results can also be used to identify differential effects on the welfare of groups within the economy defined by their ownership of factors and/or their patterns of consumption.

Coxhead and Jayasuriya (2003b) set out a modeling strategy for the general equilibrium analysis of economic and environmental phenomena in a developing economy with trade policies, spatial variation, and open-access forest lands. The main technological and behavioral relationships of the basic model are derived from the first-order conditions of revenue, cost, and utility functions, which we now sketch in highly stylized form.[11] For a competitive economy consisting of N products and F primary factors, define the following variables and vectors (vectors in bold; set size in parentheses):

$\mathbf{P}$	commodity prices (N)	$\mathbf{W}$	mobile factor prices (F)
$\mathbf{R}$	sector-specific factor prices (N)	$\mathbf{Y}$	domestic commodity supplies (N)
$\mathbf{X}$	mobile factor demands ($N \times F$)	$\mathbf{D}$	domestic final demands (N)
$\mathbf{S}$	net imports (N)	$\mathbf{V}$	factor endowments (F)
U	aggregate utility (1)	ϕ	Foreign currency exchange rate (1)

Suppose factor endowments and commodity prices to be given, and let $\phi = 1$ be the numéraire price. Aggregate revenue (i.e. GNP) is given by

[11] This exposition also draws on Bandara and Coxhead (1999).

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$G(\mathbf{P}, \mathbf{V}) = \max\{\mathbf{P} \cdot \mathbf{Y} \mid \mathbf{V}\}$; from the first-order conditions of this problem we obtain, using the envelope theorem, the sectoral supply functions

$$Y_j = Y_j(\mathbf{P}, \mathbf{V}) \quad (j = 1, \ldots, N) \tag{1}$$

and the prices of mobile and specific factors

$$W_i = W_i(\mathbf{P}, \mathbf{V}) \quad (i = 1, \ldots, F) \tag{2}$$

$$R_j = R_j(\mathbf{P}, \mathbf{V}). \quad (j = 1, \ldots, N) \tag{3}$$

Firms in each sector are assumed to be price-takers in factor markets. Therefore, the output level that maximizes revenue is also the cost-minimizing level, and from the first-order conditions of the sectoral cost minimization problem $C_j(\mathbf{W}, Y_j) = \min\{\mathbf{W} \cdot \mathbf{X} \mid Y_j)$, we obtain demands for intersectorally mobile factors

$$X_{ij} = X_{ij}(\mathbf{W}, Y_j) \quad (i = 1, \ldots, F; j = 1, \ldots, N) \tag{4}$$

Domestic final demands for each commodity are found by the envelope theorem from the first-order conditions of the consumer's expenditure minimization problem $E(\mathbf{P}, U) = \min\{\mathbf{P} \cdot \mathbf{D} \mid U\}$

$$D_j = D_j(\mathbf{P}, U) \quad (j = 1, \ldots, N) \tag{5}$$

Net commodity trade volumes are determined by market-clearing conditions

$$S_j = D_j - Y_j \quad (j = 1, \ldots, N) \tag{6}$$

where $S_j > (<) 0$ indicates a net import (export) good. Import prices are set in world markets, while for M exportables ($M \leq N$), prices are set by inverse foreign demand functions

$$P_k = P_k(S_k) \quad (k = 1, \ldots, M) \tag{7}$$

Finally, the model is closed by an aggregate budget constraint

$$E(\mathbf{P}, U) = G(\mathbf{P}, \mathbf{V}) \tag{8}$$

In an economy with complete and competitive markets and constant returns to scale, it is a condition of equilibrium that factor and product markets clear, aggregate expenditure is equal to income, and trade is in balance. In the basic model just sketched, factor market clearing is implied by the conditions for revenue maximization, and the markets for non-traded commodities (for which $S_j = 0$) clear by equation (6). Aggregate expenditures are set equal to income in equation (8). By Walras' law, when these conditions are all met the balance of trade is also zero, thus satisfying the conditions for general equilibrium.

This simple model presents the key features of any larger construct, albeit in spare and highly simplified form. It can be solved to yield the central insights of a general equilibrium analysis: economy-wide determination of price and incomes, the structure of production, consumption and trade, and household welfare. Simple extensions to the model permit policy analysis. Trade taxes, for example, can be brought in by defining domestic commodity prices as equal to world market prices (in domestic currency units) raised

or lowered by trade taxes τ, so that $P_j = P_j^*(1 + \tau_j)$ for all goods j, where P_j^* denotes the border price.

The choice of *closure* is an important decision for any general equilibrium modeling exercise. In a strictly technical sense, specifying the closure means choosing a subset of variables to be exogenous, such that the number of endogenous variables is just equal to that of equations. The system of equations (1) to (8) contains $4N + F + FN + M + 1$ equations, but $5N + 2F + FN + 2$ variables. A solution thus requires that $(N - M + F + 1)$ variables be declared exogenous. In a short-run neoclassical closure, **V** (the factor endowment vector) is declared exogenous, and so is a subset $(N - M)$ of the vector **P**. The exchange rate ϕ is selected as an exogenous numéraire price. The number of equations is thus made equal to the number of endogenous variables, and (1) to (8) solve for **Y**, **W**, **R**, **X**, **D**, **S**, U, and the M endogenous elements of **P**.

Selecting a closure, however, implies more than just the satisfaction of an algebraic rule. It also reflects assumptions about important structural features of an economy, and where these are not known with certainty, alternative closures may be specified and compared by selecting different combinations of variables to be exogenous. In some economies, for example, the assumption of a fixed wage with 'slack' (unemployment) in the labor market may be judged to be more empirically robust than that of a flexible nominal wage and full employment. The closure reflecting this requires fixing W_L exogenously, and allowing the value of the corresponding factor endowment, V^L (interpreted as total employment), to be solved within the model. Similarly, if land area is assumed adjustable in the short to medium run, then the supply of 'fallow' land may be set endogenous and the nominal land price fixed. Varying these assumptions and comparing the results obtained is an important and intuitive form of sensitivity analysis, as will be demonstrated in the next section.[12] These closures may also capture differences between short-run and long-run economic responses to a shock.

Applied general equilibrium analysis

The rigorous analysis of questions about the fundamental determinants of environmental change is exceptionally difficult. While the broad nature of the economic forces that operate can be gleaned from stylized models, actual outcomes depend on complex economy-wide interactions, and this justifies a numerical approach. In the remainder of this paper we present the results of numerical simulations using the APEX AGE model of the Philippine economy.

APEX (Agricultural Policy Experiments) is an applied general equilibrium model of the Philippine economy developed in a collaborative venture by researchers at the Australian National University and the Philippine Department of Agriculture (Clarete and Warr, 1992). APEX is

[12] In any case of endogenous factor endowments, a given shock affects household incomes somewhat differently by comparison with the fixed endowment case. With fixed endowments, household incomes depend only on endogenous factor price changes; when factor supplies are endogenous, household incomes from ownership of those factors rise and fall with the quantity supplied.

a conventional, real, micro-theoretic general equilibrium model designed to address microeconomic policy issues for the Philippines. It belongs to the class of models (sometimes known as Johansen models) that are linear in proportional changes of variables. APEX shares many features with the well-known ORANI model of the Australian economy (Dixon *et al*., 1982), although these features have been adapted to fit the realities of the Philippine economy. Input–output data in APEX are drawn from the Philippine Social Accounting Matrix (Clarete and Cruz, 1992). Unlike most other AGE models of comparable size, however, in APEX all parameters describing technology and preferences are constructed from original econometric estimates.[13]

While preserving the same basic framework as the model sketched in the previous section, APEX is considerably more complex. It allows for intermediate inputs; for inputs and products distinguished by source (domestic or foreign), and distinguishes different kinds of labor input (skilled and unskilled). Final demands for domestic and imported commodities are also distinguished by use category – households, government, net trade, and capital creation. Domestic and foreign goods within the same commodity category are differentiated by origin, so domestic and foreign prices may differ. The model also contains direct taxes on household and corporate income, as well as a range of indirect taxes: excise taxes, value-added taxes, and import tariffs.

The model contains 50 producer goods and services produced in 41 industries. There are 38 manufacturing and services sectors and 12 agricultural sectors, with spatially distinct agricultural production as described below. Producer goods are aggregated into seven consumer goods. There are five households, each representing a quintile of the income distribution and having unique income and consumption characteristics.

Consumer demands are all described by flexible functional forms. Similarly, factor demands and the aggregation of factors of different types all depend on flexible functional forms, allowing for substitution in response to changing relative prices. In agricultural production, primary factors and fertilizer are aggregated, using a flexible functional form with econometrically estimated parameters, into a composite 'primary factor' input which is assumed to be used with intermediate goods (other than fertilizer) in fixed proportions. This structure is thus flexible enough to permit primary factor substitution in response to changes in the relative prices of primary factors and fertilizer. Finally, imports and their domestically produced substitutes are aggregated using CES forms with econometrically estimated Armington elasticities. Other details of the model structure can be found in Clarete and Warr (1992), and some illustrative experiments and associated

[13] A more complete description of the model, as well as working papers describing the data sets, econometric procedures, and estimation results, can be obtained from the APEX home page, housed in the Poverty Research Centre, Division of Economics, Research School of Pacific and Asian Studies, Australian National University: http://rspas.anu.edu.au/economics/apex.

Table 2. *Sector shares in gross domestic product (per cent)*

Sector	*Share*	*Sector*	*Share*
Irrigated rice	3.49	Beverages & tobacco	1.02
Rainfed rice	0.32	Textiles & knitting mills	1.15
Corn	1.70	Other made-up textile goods	0.35
Coconut	1.17	Garments, footwear, leather, rubber footwear	2.37
Sugar	0.66		
Banana & other fruit & nuts	1.59	Pulp products	0.75
		Wood & Paper products	0.73
Vegetables	0.80	Fertilizer	0.15
Root crops	0.34	Other rubber, plastic & chemical products nec	1.75
Other comm'l crops nec	3.76		
Hogs	1.42	Petroleum products	0.63
Poultry	2.32	Coal & Non-ferrous basic metals	1.34
Other livestock nec	0.43	Cement, basic metals, non-metallic minerals	1.48
Ag. services	0.05		
Marine fisheries	3.57	Semiconductors	0.96
Inland fisheries	1.11	Other metal products	0.99
Forestry	1.26	Electrical machinery	0.70
Crude oil, coal & nat. gas	0.21	Transport equipment	0.22
Other mining	1.47	Misc. manufacturing	0.63
Rice & corn milling	2.40	Construction	4.72
Sugar milling	0.45	Electricity, gas & water	2.53
Milk & dairy products	0.38	Transport & comm services	4.40
Fats & oils	1.53	Trade, wholesale & storage	19.90
Meat processing	1.41	Banking services	1.43
Flour milling	0.15	Insurance & real estate serv.	5.23
Animal feeds	0.32	Government services	7.92
Other foods	0.21	Other services nec	6.12
		TOTAL	100.00
		Agriculture	18.02
		Natural resources	7.63
		Processed food & feed	7.86
		Other manufacturing	14.20
		Services	52.29

Source: APEX database.

discussion in Warr and Coxhead (1993) and Coxhead and Jayasuriya (2003a, 2003b).

In addition to solving for price and quantity responses to a given shock, we are interested in a variety of aggregate economic magnitudes such as employment, GDP, government revenues and expenditures, income distribution, and approximations to measures of economic welfare. These are computed in the APEX by means of appropriate addition and aggregation rules. The model is solved in linearized form using Gempack software (Harrison and Pearson, 1996). Tables 2 and 3 show, for the 50 APEX sectors, some basic information from the model database on relative sectoral size and labor intensity.

Table 3. *Sector shares in labor employment (per cent)*

	Employment share	
Sector	*Unskilled*	*Skilled*
Agriculture: Luzon	21.37	0.00
Agriculture: Visayas	5.34	0.00
Agriculture: Mindanao	6.68	0.00
Ag. services	0.07	0.05
Marine fisheries	5.31	1.28
Inland fisheries	1.32	0.32
Forestry	1.01	0.40
Crude oil, coal & nat. gas	0.10	0.10
Other mining	1.30	1.41
Rice & corn milling	2.26	2.51
Sugar milling	0.27	0.30
Milk & dairy products	0.21	0.24
Fats & oils	1.21	1.34
Meat processing	1.03	1.14
Flour milling	0.11	0.13
Animal feeds	0.28	0.31
Other foods	0.17	0.19
Beverages & tobacco	0.75	0.83
Textiles & knitting mills	1.23	1.10
Other made-up textile goods	0.37	0.33
Garments, footwear, leather, rubber footwear	3.39	3.03
Wood & pulp products	0.83	0.85
Paper products	0.70	0.72
Fertilizer	0.10	0.15
Other rubber, plastic & chemical products nec	1.24	1.91
Coal & petroleum products	0.12	0.19
Non-ferrous basic metals	0.51	0.56
Cement, basic metals, non-metallic minerals	0.83	0.90
Semiconductors	0.98	1.27
Other metal products	0.89	1.16
Electrical machinery	0.61	0.79
Transport equipment	0.22	0.28
Misc. manufacturing	0.74	0.72
Construction	5.99	5.63
Electricity, gas & water	0.94	1.47
Transport & comm services	4.11	4.93
Trade, wholesale & storage	15.89	16.36
Banking services	0.70	3.52
Insurance & real estate serv.	0.67	3.35
Government services	5.27	30.20
Other services nec	4.88	10.05
TOTAL	100.00	100.02
Agriculture	33.39	0.00
Natural resources	9.04	3.51
Processed food & feed	6.29	6.98
Other manufacturing	12.76	13.96
Services	38.51	75.55

Source: APEX data base.

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Land use and deforestation pressures in APEX

The base form of APEX contains no explicit environmental information. However, for a given policy reform simulation it does provide detailed predictions of input and output changes at the industry level, as just described. Environmental implications can then be derived through additional calculations.

Agriculture, in APEX, produces a vector of goods using land, capital, unskilled labor and fertilizer as well as intermediate inputs. Production takes place in the three regions, Luzon, Visayas, and Mindanao. Each region has endowments of land and capital that are specific to agricultural uses, while labor and variable capital are assumed intersectorally as well as interregionally mobile. Agricultural inputs are non-allocable due to data constraints, so the model cannot directly identify the quantity of each input used in the production of any individual agricultural output. Rather, the model operates as though farmers in each region purchase a production possibilities frontier, then choose their location on the frontier – that is, the product mix – in response to relative output prices.

Within this structure, some groups of agricultural products are presumed to be jointly produced. One such group is the category 'rainfed crops', which consists of rainfed rice, corn, and root crops. We identify this sub-aggregate as the set of agricultural crops in which the potential for measurable soil fertility reduction through erosion can take place. Value-added in the rainfed crops sector is dominated by corn, with 60 per cent of sectoral value-added; root crops account for 28 per cent, and rainfed rice 12 per cent. Empirically, these crops (mainly corn and rainfed rice) account for the greatest part of land use in Philippine uplands. Erosion in uplands comes mainly from their production, primarily that of corn (Coxhead and Shively, 1998). Thus changes in the area of corn and rainfed rice determine erosion outcomes in the model.

The joint production function for rainfed crops is nested within that for agriculture as a whole in each region. The composition of production within the rainfed crops sector is altered when the relative prices of the three crops change. Similarly, the share of rainfed crops in total agricultural production depends on prices of the sub-aggregate relative to those of other agricultural sectors. Each of the three rainfed crops is classed as an importable in APEX, although in practice the shares of imports in total domestic availability are very small due to long-standing trade restrictions. In practical terms, this means that while international prices and related trade policies are influential, domestic demand and supply fluctuations are arguably the primary determinants of price and quantity changes.

For a given exogenous shock, the model provides predictions of land use changes among and within agricultural subsectors. These results can be used in conjunction with crop- and slope-specific estimates of soil erosion rates to calculate the likely effects of a given change on pressures for agricultural expansion and, by implication, deforestation. In the model, this mechanism works through changes in agricultural land returns by crop; upward pressure on land returns results in an expansion of area planted for that crop. Erosion changes by crop depend on area planted; net erosion changes by region depend on the mix of crops and the total area farmed (for more details, see Coxhead and Shively, 1998).

Analyzing poverty changes

The model does not generate a measure of poverty change *per se*, but it does provide all the information required to calculate changes in the welfare of poor households. Sen (1981) aggregates these factors into *production entitlements* (the capacity to produce output from own resource endowments) and *exchange entitlements* (the terms of trade at which the poor engage in exchange with the rest of the economy). In this classification, forest clearing by the poor can be interpreted as an effort to increase production entitlements – that is, to increase productive capacity by acquiring either more land or more productive land. The commercialization of agriculture, which is ubiquitous in the Philippine case, means that exchange entitlements – as reflected in wages and the prices of goods produced and consumed by the poor – are also important. Both types of entitlement are affected by distortions; open access to forest confers opportunities for upland farmers to increase production entitlements at low cost other than their own labor, while the general equilibrium effects of trade policies and other market interventions affect prices paid and received by farmers for labor and goods. These are indirect channels through which poverty and the environment interact. As an example, policy reforms that increase profits in labor-intensive manufacturing industries tend to raise wages for unskilled labor; other things equal this represents an improvement in the exchange entitlements of the poor and reduces pressures on land and forest by drawing labor away from farming and other natural resource sectors and into urban, non-farm occupations.

Analytically, the causes of poverty change may be identified through their influences on the well-being of the poor by identifying changes in production and exchange entitlements, as follows. Define factor returns by a vector $\mathbf{W}$, endowments (per household) by $\mathbf{V}^h$, and prices by $\mathbf{P}$; let T^h be transfers or lump-sum taxes, τ^h the rate of income tax, and $\phi^h = \prod_j P_j^{\alpha_j^h}$ a consumer price index over j goods, with household-specific budget shares α_j^h comprising the weights. The real disposable income of a poor household is then

$$I^h = \frac{\mathbf{W} \cdot \mathbf{V}^h + T^h}{(1 - \tau^h)\phi^h} \tag{9}$$

Converting (9) to proportional changes of variables provides a measure of change in real household income. Let $\hat{I}^h = dI^h/I^h$, and similarly for the other variables. Then

$$\hat{I}^h = \sum_i (\hat{W}_i + \hat{V}_i^h)\gamma_i^h + \hat{T}^h\gamma_T^h - \beta^h\left[\left(\frac{1+\tau}{\tau}\right)\hat{\tau} + \sum_j \hat{P}_j\alpha_j^h\right], \tag{10}$$

in which the parameters γ_i^h and γ_T^h are shares of factor endowments and transfers, respectively, in gross household income, and $\beta^h = [(1+\tau)\phi]^2$. Changes in V^h are production entitlement changes, while those in the Ws, Ps, τ and T^h represent exchange entitlement changes. Thus, as an example, a trade policy shock affecting commodity prices may generate additional factor income for households, while at the same time reducing real income through increases in consumer prices; if the policy change also

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affects government finances, then household income may also be altered by endogenous changes in the rate of income tax or government transfers.

In general equilibrium, factor prices and product prices are themselves determined by endowments, national market prices and any policies affecting them, as seen in simplified form in the previous section. Similarly, household endowment vectors are determined – at least in part – by the institutional environment governing access to non-labor factors, including forested land for conversion to agriculture. Thus (10), embedded within an appropriate general equilibrium framework, can be used to predict changes in household welfare consequent on changes in individual policies, world prices, or access to resources. In a model with sufficiently many households, such that the group initially classed as poor can be separately identified in terms of incomes and expenditure patterns, predictions of poverty change are made simultaneously with predictions of changes in production and the demand for resources, including forested land to be cleared for agricultural cultivation. The APEX model thus permits an analysis of the effects of policy or other exogenous changes on deforestation both directly, and also indirectly through changes in the causes of household poverty.

5. The impacts of trade policy reforms

The EO470 trade reform program

To illustrate the possible environmental effects of broad-based trade policy reform, we use APEX to examine the predicted outcomes of tariff changes mandated in the EO470 trade liberalization package. Under EO470, the average tariff rate was to fall from about 28 per cent to about 20 per cent over 1992–1995 (table 4). An important aspect of EO470, however, was that in spite of a reduction in the *average* rates, the overall *dispersion* of nominal tariff rates increased under the reform. As the table shows, a large part of the increased dispersion can be attributed to differential treatment for agricultural sectors: there was to be no change in the rice tariff and a 17 per cent increase in that for corn, the other large agricultural import. By comparison with pre-reform levels, the standard deviation of all tariffs rose from 11 per cent to more than 13 per cent; under EO470 the average decline for tariffs initially above the mean was 10 per cent, but that for those initially below the mean it was 18 per cent.[14]

Although EO470 was superseded in the late 1990s by reforms associated with the Philippines' accession to the WTO, the later reforms have shared both the trend to a lower average tariff and the pro-agriculture bias of EO470. Quantitative restrictions, which applied mainly in agriculture, were converted into tariffs during the 1990s at prohibitively high rates (Tan, 1995), with the ironic result that after decades during which trade policy

[14] The exact change depends on how sectors are aggregated. In her comprehensive study of EO470, Tan (1995, Table 2.5, p. 183) found that the reform caused a slight increase in the standard deviation of tariffs on importable goods, from 12.9 per cent in 1990 to 13.2 per cent in 1995, based on book values, and from 22.5 per cent to 23.0 per cent based on price comparisons (Table 2.6, p. 188).

Table 4. *Initial tariff rates and EO470 tariff reforms (per cent)*[a]

Sector	*Trade status*[b]	*Initial tariff rate (%)*	*EO470 (% change)*
Irrigated rice	M	41.93	0.00
Rainfed rice	M	41.93	0.00
Corn	M	16.77	16.65
Coconut	X	16.77	150.00
Sugar	M	41.93	0.00
Banana & other fruit & nuts	X	41.93	− 13.33
Vegetables	M	34.11	− 29.99
Root crops	M	38.58	− 24.78
Other comm'l crops nec	X	28.50	110.00
Hogs	M	8.39	− 36.35
Poultry	M	36.98	− 20.51
Other livestock nec	M	19.14	− 70.00
Ag. services	M	8.39	8.16
Marine fisheries	X	20.96	− 50.50
Inland fisheries	N	26.68	− 25.08
Forestry	M	14.86	− 39.19
Crude oil, coal & nat. gas	M	12.50	− 24.91
Other mining	X	17.82	0.00
Rice & corn milling	M	41.93	− 5.72
Sugar milling	X	41.93	− 8.33
Milk & dairy products	M	17.67	− 12.32
Fats & oils	M	30.37	− 17.24
Meat processing	N	30.40	0.77
Flour milling	M	22.83	− 25.63
Animal feeds	M	19.17	− 25.52
Other foods	X	37.73	− 8.11
Beverages & tobacco	M	36.79	− 32.08
Textiles & knitting mills	M	33.12	− 26.89
Other made-up textile goods	X	37.74	− 15.46
Garments, footwear, leather, rubber footwear	X	34.61	− 26.27
Wood & pulp products	X	30.57	− 36.46
Paper products	M	25.61	− 59.00
Fertilizer	M	4.19	− 1.22
Other rubber, plastic & chemical products nec	M	21.91	− 40.24
Coal & petroleum products	M	12.80	− 24.14
Non-ferrous basic metals	X	15.29	− 22.79
Cement, basic metals, non-metallic minerals	M	21.60	− 58.10
Semiconductors	X	19.46	− 32.20
Other metal products	M	27.39	− 29.18
Electrical machinery	M	14.88	− 31.32
Transport equipment	M	10.36	− 20.23
Misc. manufacturing	M	23.18	0.00
Weighted averages:			
Agriculture		30.87	24.15
Natural resources		19.95	− 34.47

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Table 4. *Continued*

Sector	*Trade status*[b]	*Initial tariff rate (%)*	*EO470 (% change)*
Processed food & feed		34.38	– 11.91
Other manufacturing		11.36	– 12.23
Total		27.78	– 7.93

Notes: [b] M: import-competing; X: exportable; N: non-traded. [a] Excluding nontraded services sectors.
Source: Clareteand dela Peña (1992) and authors' calculations.

discriminated against agriculture, rice, corn, and some other crops ended up being among the most heavily protected industries in the economy (WTO, 1999; David, 2003, table 6.9; Bautista and Tecson, 2003).

APEX closure and 'shocks'

The model closure chosen for the trade reform simulations embodies numerous assumptions about the nature of the Philippine economy. External trade and the government budget are assumed to be in balance initially, and the economy must adjust following a 'shock' (such as the exogenous revision of tariff rates) to restore these balances. Supplies of all primary factors (unskilled labor, skilled labor, land, and capital) are initially assumed fixed so that their markets clear through factor price adjustments – though we subsequently alter this assumption to allow for 'slack' in labor and land markets. The remaining details of the macroeconomic closure are chosen to ensure that the burden of adjustment to a shock falls entirely on household expenditures.[15] The model thus yields a measure of welfare change based on increases or declines in real household consumption expenditures. Disaggregation of household results by sources of income and expenditure patterns permits a fairly detailed analysis of likely changes in poverty.

Two modifications to this closure are important to consider in the Philippine context; these concern the supply of unskilled labor and agricultural land. Empirically, the market for unskilled labor has frequently been characterized by considerable unemployment and underemployment. The elasticity of supply of unskilled labor is not known, however. Given such uncertainty it makes sense to examine the effects of trade shocks under an alternative labor market assumption, that of flexible supply at a fixed nominal wage.

For agricultural land, there is some capacity for farmers to bring land in and out of production in response to short-run stimuli (this is particularly true of uplands, where fallowing is a standard response to adverse economic signals and, conversely, fallowed land can quickly be brought back into production). We therefore assume, in an alternate closure, that agricultural

[15] Specifically, any shortfall or surplus in the government budget is made up by a lump-sum tax on household incomes, while nominal household savings remain fixed.

acreage can be altered in the short to medium run, in effect creating a flexible supply of land at a constant nominal unit price. In other words, at the margin there is fallow land that can be brought into production, or planted land that that can be fallowed. This permits the model to capture pressures for agricultural expansion or contraction in response to economy-wide shocks. In the Philippines, where old-growth forests are a small proportion of total forest cover and agricultural expansion accounts for most new deforestation, agricultural expansion at the margin can be read as a proxy for deforestation pressures.

In the EO470 simulation experiment we conduct a form of 'structural sensitivity analysis' by adopting three alternative closures to reflect these differing market assumptions. The 'base' case is that of fixed quantities of all factors, a neoclassical full employment closure. In the 'unemployment' closure we assume that there is slack in the market for unskilled labor, such that employment growth can occur at a fixed nominal wage. In the 'unemployment + fallow' closure we assume in addition that the supply of agricultural land is also flexible, at a fixed nominal unit price. The latter two closures appear to fit better with the stylized facts of the Philippine economy, and as such are our preferred choices for policy discussion.

Economic impacts of EO470

We simulate the effects of EO470 by applying a tariff shock in which initial tariff rates are altered by the percentage changes shown in table 4. Changes in major macroeconomic variables occurring as the result of the trade policy reform are shown in table 5. Sectoral output and price changes are found in table 6, employment changes in table 7, and factor price and supply changes in table 8. These are *ceteris paribus* changes; in the real world, of course, tariff reform is implemented along with many other types of reform; our experiment captures only one element of the entire package.

For the 'base' closure, table 5 shows that trade policy reforms have a very small negative effect on aggregate welfare, measured as the sum of real household consumption expenditures. In an economy distorted by a number of taxes, of which tariffs are only one type, there is neither any expectation nor any assurance that the tariff reduction by itself will raise welfare. The observed small negative effect on aggregate real consumption may well be due to rounding errors, reflecting basically unchanged overall welfare. From table 8 we see that trade liberalization – whether applied only to manufacturing or to all sectors – has a pro-labor impact, and real wages of both skilled and unskilled labor increase, with the latter increase being about three times greater than the former. Returns to variable capital also rise, but those to specific capital in formerly protected sectors decline.[16] Intersectoral variations in returns to specific capital indicate pressures for investment or disinvestment in the next period, although of course the model itself, being static, does not quantify actual investment responses.

It can be seen from the sectoral results in table 6 that trade liberalization, as expected, generally reduces output in the import-competing manufacturing

[16] The latter figures, although not shown in the tables, are available as part of the complete set of simulation results from the authors.

Table 5. *Macroeconomic effects of trade liberalization (per cent changes)*

	Base	*Unemployment*	*Unemp + fallow*
Overall economy			
Gross domestic product (factor prices)			
Nominal (local currency)	0.98	1.08	1.09
Real	− 0.01	0.08	0.09
Consumer price index	0.17	0.16	0.16
GDP deflator	0.99	0.99	1.00
External sector			
Export revenue (foreign currency)	0.52	0.57	0.57
Import bill (foreign currency)	0.50	0.55	0.55
Trade deficit (in levels, foreign currency)	0.0*	0.0*	0.0*
Government budget			
Revenue			
Tariff revenue	− 20.14	− 20.09	− 20.09
Aggregate revenue			
Nominal, local currency	0.67	0.83	0.82
Real	0.50	0.47	0.66
Expenditures			
Nominal (local currency)	0.67	0.83	0.82
Real	0.50	0.47	0.66
Budget deficit (in levels, local currency)	0.0*	0.0*	0.0*
Household sector			
Consumption			
Nominal (local currency)	0.14	0.23	0.22
Real	− 0.03	0.08	0.07

Note on closures: 'Base': full employment, fixed land area; 'Unemployment': variable employment, fixed nominal wage, fallow area; 'Unemployment + fallow': variable employment, variable land area.
Source: APEX simulation results. 0* indicates figure is identically zero.

sectors, which receive the highest initial protection, and increases it in the labor-intensive electronics sector ('semiconductors'), made-up textiles, and in several resource-based industries, including forestry and mining. At the same time, agricultural sectors also contract. The agricultural contraction can readily be understood in terms of two effects. First, profitability in the sector is reduced by the unskilled labor cost increase (table 8). Unskilled labor demand rises in semiconductors, wood products, 'other foods' processing, mining, forestry, and construction, and labor-intensive agricultural sectors must compete with these additional demands. Second, with inelastic domestic demand and only limited capacity to dispose of additional production through trade, the higher *relative* protection awarded to agriculture under EO470 does not translate into substantial price increases; in fact corn, for which the tariff actually rises, nevertheless suffers an output price decline. These effects emerge as large falls in agricultural land prices, especially in corn-intensive Mindanao.

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Table 6. *Domestic production changes (per cent) under EO470 reforms*

	Base		*Unemployment*		*Unemp + fallow*	
Sector	*Output*	*Price*	*Output*	*Price*	*Output*	*Price*
Irrigated rice	−0.33	0.13	−0.17	−0.20	−0.18	−0.16
Rainfed rice	−0.36	0.13	−0.23	−0.20	−0.24	−0.16
Corn	−0.63	−0.19	−0.48	−0.57	−0.49	−0.50
Coconut	−0.24	0.33	0.02	0.05	−0.01	0.08
Sugar	−0.31	0.07	−0.14	−0.21	−0.15	−0.19
Banana & other fruit & nuts	−0.37	0.06	0.01	−0.06	−0.04	−0.04
Vegetables	−0.26	0.12	−0.13	−0.21	−0.13	−0.17
Root crops	−0.26	0.27	−0.13	−0.08	−0.13	−0.07
Other comm'l crops nec	−0.12	0.05	0.09	−0.05	0.07	−0.03
Hogs	−0.03	0.32	0.10	−0.02	0.09	0.01
Poultry	−0.04	0.47	0.10	0.12	0.09	0.15
Other livestock nec	−0.17	0.39	−0.03	0.04	−0.04	0.07
Ag. services	−0.28	0.01	−0.12	0.02	−0.13	0.01
Marine fisheries	−0.36	0.17	−0.22	0.15	−0.21	0.15
Inland fisheries	−0.02	0.41	0.11	0.43	0.10	0.42
Forestry	1.19	1.25	1.21	1.24	1.22	1.23
Crude oil, coal & nat. gas	0.06	−0.37	0.08	−0.32	0.08	−0.32
Other mining	0.72	−0.19	0.66	−0.18	0.68	−0.19
Rice & corn milling	−0.32	0.36	−0.19	0.19	−0.19	0.21
Sugar milling	−0.32	0.08	−0.14	0.03	−0.16	0.03
Milk & dairy products	−0.02	−1.17	0.11	−1.13	0.10	−1.13
Fats & oils	0.02	−0.04	0.08	−0.05	0.08	−0.05
Meat processing	0.00	0.46	0.12	0.29	0.11	0.30
Flour milling	−0.80	9.19	−0.66	9.19	−0.67	9.19
Animal feeds	−1.94	−0.01	−1.75	−0.14	−1.77	−0.12
Other foods	0.36	−0.28	0.52	−0.32	0.51	−0.31
Beverages & tobacco	−0.18	0.10	−0.11	0.13	−0.11	0.13
Textiles & knitting mills	−0.91	−0.22	−0.79	−0.20	−0.79	−0.21
Other made-up textile goods	0.41	−0.19	0.52	−0.22	0.52	−0.21
Garments, footwear, leather, rubber ftwr	−0.92	0.16	−0.85	0.16	−0.84	0.16
Wood & pulp products	2.92	−0.47	2.90	−0.46	2.92	−0.46
Paper products	−0.85	−0.47	−0.76	−0.42	−0.77	−0.43
Fertilizer	−0.01	−0.07	−0.07	−0.05	−0.02	−0.04
Rubber, plastic & chem products nec	0.02	−0.93	0.08	−0.89	0.07	−0.89
Coal & petroleum products	−0.03	−0.12	0.01	−0.07	0.00	−0.08
Non-ferrous basic metals	−0.49	0.09	−0.54	0.11	−0.53	0.10
Cement, basic metals, non-metallic min	−1.21	−1.05	−1.19	−1.00	−1.19	−1.01
Semiconductors	3.16	−0.49	3.06	−0.48	3.08	−0.48
Other metal products	−0.54	−2.45	−0.49	−2.45	−0.49	−2.45
Electrical machinery	−0.48	−1.12	−0.47	−1.09	−0.47	−1.10
Transport equipment	−0.27	−1.12	−0.28	−1.09	−0.28	−1.10
Misc. manufacturing	−0.08	−0.01	−0.02	0.01	−0.02	0.00

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Table 6. *Continued*

	Base		*Unemployment*		*Unemp + fallow*	
Sector	*Output*	*Price*	*Output*	*Price*	*Output*	*Price*
Construction	0.26	− 0.58	0.28	− 0.57	0.28	− 0.58
Electricity, gas & water	0.02	0.25	0.02	0.34	0.08	0.33
Transport & comm services	0.16	0.53	0.16	0.62	0.17	0.61
Trade, wholesale & storage	− 0.11	0.57	− 0.02	0.61	− 0.02	0.59
Banking services	0.10	0.66	0.18	0.81	0.17	0.79
Insurance & real estate services	0.14	0.72	0.21	0.89	0.20	0.88
Government services	0.04	1.18	0.04	1.44	0.04	1.42
Other services nec	− 0.05	0.09	0.04	0.15	0.03	0.14

Note on closures: 'Base': full employment, fixed land area; 'Unemployment': variable employment, fixed nominal wage, fallow area; 'Unemployment + fallow': variable employment, variable land area.

The middle column of results in each table shows the effects of the EO470 reforms in the 'unemployment' closure. Overall, the results are broadly similar, but some macroeconomic differences are evident. In particular, the reforms increase labor demand, which in this closure stimulates an increase in unskilled labor employment. Aggregate welfare rises – as might be expected, other things equal, when the economy in effect acquires additional supplies of a productive factor. The additional labor supply dampens many of the sectoral impacts of the reform, with the notable result that agricultural output and employment decline by less than in the base case (tables 6 and 7).

In the 'unemployment + fallow' closure, shown in the third column of each table, there are few differences from the 'unemployment' closure. The declining demand for agricultural land, with a flexible supply, sees some acreage removed from production in response to declining agricultural incentives.

Environmental impacts

The net environmental effects of the trade reform in land-using industries arise from expanding output of the 'commercial forestry' sector and the contraction of most agricultural industries. In the forestry sector, EO470 brings about a rise in the producer price, and timber production expands. What happens to this commercial timber sector in the long run as a result of trade reforms depends on the nature of property rights. If property rights in forestry were well-defined and enforced – an assumption that is implicit in the model structure – then an increase in the relative price of forestry would promote a sustained expansion of timber output, which in an intertemporal context would imply increased investment in timber tree stocks. On the other hand, if property rights were not well defined or not enforced, then by raising the stumpage value of existing trees, trade liberalization that

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Table 7. *Unskilled labor employment changes (per cent) under EO470 reforms*

Region/sector	*Base*	*Unemployment*	*Unemp + fallow*
Agriculture: Luzon	− 0.51	− 0.24	− 0.13
Agriculture: Visayas	− 0.62	− 0.16	− 0.16
Agriculture: Mindanao	− 0.90	− 0.37	− 0.26
Ag. services	0.17	0.77	0.75
Marine fisheries	− 0.34	0.38	0.38
Inland fisheries	0.42	1.10	1.08
Forestry	2.87	3.23	3.24
Crude oil, coal & nat. gas	0.45	0.79	0.78
Other mining	1.86	2.02	2.05
Rice & corn milling	− 0.13	0.38	0.37
Sugar milling	− 0.11	0.63	0.60
Milk & dairy products	0.41	0.96	0.94
Fats & oils	0.41	0.88	0.87
Meat processing	0.45	1.03	1.01
Flour milling	− 0.82	− 0.33	− 0.35
Animal feeds	− 2.50	− 1.92	− 1.95
Other foods	0.96	1.56	4.54
Beverages & tobacco	0.16	0.64	0.63
Textiles & knitting mills	− 0.60	− 0.12	− 0.13
Other made-up textile goods	0.91	1.42	1.41
Garments, footwear, leather, rubber footwear	− 0.52	0.05	0.06
Wood & pulp products	5.30	5.67	5.69
Paper products	− 0.96	− 0.41	− 0.43
Fertilizer	0.30	0.47	0.56
Other rubber, plastic & chemical products nec	0.37	0.74	0.73
Coal & petroleum products	0.29	0.67	0.66
Non-ferrous basic metals	− 0.69	− 0.56	− 0.54
Cement, basic metals, non-metallic minerals	− 2.12	− 1.83	− 1.83
Semiconductors	5.24	5.37	5.39
Other metal products	− 0.34	0.07	0.06
Electrical machinery	− 0.25	0.10	0.10
Transport equipment	− 0.03	0.25	0.25
Misc. manufacturing	0.38	0.85	0.84
Construction	1.06	1.52	1.52
Electricity, gas & water	0.29	0.62	0.61
Transport & comm services	0.68	0.99	0.99
Trade, wholesale & storage	− 0.02	0.24	0.23
Banking services	0.28	0.51	0.50
Insurance & real estate serv.	0.33	0.54	0.53
Government services	0.21	0.34	0.34
Other services nec	0.04	0.20	0.19

Note on closures: 'Base': full employment, fixed land area; 'Unemployment': variable employment, fixed nominal wage, fallow area; 'Unemployment + fallow': variable employment, variable land area.

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Table 8. *Changes in factor returns and supplies*

Factor	*Base*	*Unemployment*	*Unemp + fallow*
Factor prices			
Unskilled labor	0.53	–	–
Land: Luzon	− 0.69	− 0.59	–
Land: Visayas	− 0.98	− 0.39	–
Land: Mindanao	− 1.68	− 0.93	–
Skilled labor	1.58	2.03	2.01
Variable capital	1.32	1.49	1.48
Supply of variable factors			
Unskilled labor	–	0.36	0.39
Land: Luzon	–	–	− 0.12
Land: Visayas	–	–	− 0.06
Land: Mindanao	–	–	− 0.25

Source: APEX simulation results.

increases timber sector profits would instead lead to increased cutting of existing forests. In this case trade liberalization would promote accelerated deforestation.

In the base closure, the reforms raise the domestic prices of most exportable agricultural products. Corn prices, however, fall in nominal terms, and by a greater amount relative to the producer prices of other agricultural goods with which it competes for land, and corn area planted contracts (table 9). With rising labor costs, incentives to use labor to clear additional upland land for agriculture must diminish; indeed, the results under the 'fallow' closure show the area of land fallowed increasing in all regions. As a consequence of both the reduction in corn area and the contraction of farmed area overall, erosion in uplands diminishes, particularly in Mindanao. Overall, we may conclude that trade policy reform induces composition effects that are consistent with (or which at least do not run counter to) increased environmental protection in the lowland and upland/forestry ecosystems, provided that institutional failures (such as open access in commercial forestry) are not severe.

That some agricultural sectors and some exportable manufacturing sectors should contract as the result of trade liberalization requires further explanation, given that these, along with traditional exportables such as forestry and mining, are normally assumed to be the industries most negatively affected by the ISI regime. When there are many exportable and import-competing goods, each using many inputs and with differing factor intensities, the net impact on a particular sector reflects not only the change in its output price but also the complex set of changes in input prices that affect the cost of production. Sometimes, the change in output price may be more than offset by changes in input prices and overall cost of production, so that supply increases (decreases) may take place even when output prices fall (rise).

The trade policy reform simulations provide predictions about environmental structural or 'composition' effects and, in a comparative

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Table 9. *Implied land use and erosion changes (per cent) for major crops, by region*

	Base	*Unemployment*	*Unemp + fallow*
Luzon			
Irrigated rice	0.03	0.00	− 0.17
Rainfed rice	0.00	− 0.06	− 0.22
Corn	− 0.13	− 0.21	− 0.35
Coconut	0.21	0.23	0.06
Sugar	0.02	0.02	− 0.15
Banana & other fruit	0.03	0.15	− 0.03
Vegetables	0.07	0.03	− 0.13
Root crops	− 1.48	− 0.27	1.19
Other comm'l crops nec	0.06	0.17	0.00
Fallow land	–	–	0.12
Erosion	− 0.11	− 0.17	− 0.31
Visayas			
Irrigated rice	− 0.03	− 0.10	− 0.18
Rainfed rice	0.02	− 0.09	− 0.18
Corn	− 0.16	− 0.30	− 0.37
Coconut	0.20	0.17	0.08
Sugar	− 0.03	− 0.07	− 0.16
Banana & other fruit	− 0.03	0.06	− 0.04
Vegetables	− 0.03	− 0.11	− 0.19
Root crops	− 0.10	1.99	2.47
Other comm'l crops nec	0.33	0.20	0.12
Fallow land	–	–	0.06
Erosion	− 0.13	− 0.24	− 0.31
Fallow land			
Erosion	0.17	0.09	− 0.23
Rainfed rice	0.07	− 0.05	− 0.36
Corn	− 0.14	− 0.29	− 0.58
Coconut	0.21	0.22	− 0.11
Sugar	0.17	0.12	− 0.21
Banana & other fruit	0.17	0.27	− 0.07
Vegetables	0.19	0.11	− 0.21
Root crops	− 2.04	0.65	2.54
Other comm'l crops nec	0.46	0.37	0.04
Fallow land	–	–	0.25
Erosion	− 0.13	− 0.26	− 0.55

Source: APEX simulation results.

static sense, 'scale' effects (relating to the size of the economy). Calculation of longer-run growth outcomes is beyond the scope of the model; nevertheless it is clear that in the longer run, if trade policy reform leads to faster overall growth, then production of some kinds of environmental 'bads' could increase. A mix of economic policy reforms and environmental protection measures is implied, to ensure that the scale effect is not the dominant influence on the trajectory of environmental quality.

Table 10. *Changes related to poverty group (percentage change)*

	Base	*Unemployment*	*Unemp + fallow*
Labor income	0.75	1.70	1.30
Total factor inc.	0.82	1.38	1.40
Gross incomes	0.78	1.35	1.40
Disposable income	− 0.19	0.35	0.40
CPI	0.25	0.21	0.22
Real expenditure	− 0.26	0.38	0.43
All households av.	− 0.03	0.08	0.07

Note: Poverty group is lowest 40% of households by income.
Source: APEX simulation results.

Household welfare impacts

In the base closure, the tariff reforms confer proportionally larger increases on returns to factors owned mainly by wealthy households, especially intersectorally mobile capital and skilled labour, than on unskilled labor (and land returns fall). As seen in table 10, the small negative welfare change for all households conceals a substantial decline in the welfare of poor households, assumed to be the lowest 40 per cent of the income distribution.

Independent of factor market effects, which are mainly relative, the trade reforms also have regressive effects on the poor through consumer prices and the structure of the tax system. The most protected sectors produce goods consumed disproportionately by the wealthy. When tariffs are reduced, consumer price indices for wealthy households fall by more than the average price level. At the same time, the government loses revenue. Tariff revenues initially make up 25 per cent of total government revenue, so the liberalization represents a substantial drop in government income. In APEX, fiscal balance is restored by means of a lump-sum tax on all households. Though this is nominally a distributionally neutral measure, its imposition as a replacement for tariff revenues means that poor households are taxed more heavily after reform than under the tariff.

These changes, in the base closure, indicate that the short-run effect of trade reform is to *increase* the depth and severity of poverty. These effects are dramatically reversed, however, when factor supplies are assumed flexible as in the second and third closures. In these cases, which are dominated by the unskilled labor supply change, poor households gain by more than the average; trade liberalization with initial unemployment benefits the poor by creating new jobs for unskilled labor.

Comparisons with other studies

The economic effects of trade liberalization have been the focus of a number of Philippine applied general equilibrium modeling exercises. Early studies using relatively small models generally explored welfare and structural effects from generic tariff reduction experiments, but did not address environmental issues; the typical finding is that trade reform improves welfare, though not necessarily by a great deal (Yap, 2002 provides an

excellent survey of this literature). Cororaton (n.d., and in several earlier papers cited therein) simulated the effects of mid 1990s trade reforms using the PGEM model, which has 34 production sectors, five of them producing agricultural goods. His findings on sectoral incentives and overall welfare are broadly consistent with those reported here, including a predicted decline in agricultural output. Since Cororaton uses household expenditure data based on deciles of the income distribution, it is possible also to infer a decline in poverty from his results.

Other recent AGE studies, responding to changing policy priorities and improved data availability, have also extended to the measurement of environmental impacts. Aldaba and Cororaton (2001) examined the effects of trade liberalization on production of industrial emissions in the Philippines, once again using the PGEM model. Their experiments predicted relatively small *net* effects on emissions, in part because the effects of trade reform in industry sectors are themselves mixed, with some pollution-intensive industries expanding while others contract.[17] These findings, however, are limited to industrial emissions. For agriculture and natural resources there are few general equilibrium precedents to this study. Cruz and Repetto (1992) used a much simpler model to argue that liberalization would increase demands on all forms of natural resources, but their model did not distinguish among agricultural subsectors; nor did it include a complete accounting for trade in differentiated agricultural products, the mechanism that in our results drives substantial domestic price effects, and thus determines changes in resource allocation among agricultural enterprises.

6. Conclusions

This analysis of Philippine trade reforms illustrates ways in which economic policies widely implemented in developing countries can simultaneously influence environmental and poverty outcomes. The direct and indirect impacts of past Philippine development strategies aggravated deforestation and natural resource depletion rates, in some cases quite severely. These particular development strategies have done more than simply to constrain economic growth. By perpetuating poverty in rural areas they encouraged population movement to crowded cities and to ecologically fragile uplands. By distorting agricultural incentives they encouraged both the expansion of agriculture at the forest margin and the cultivation of more soil-erosive crops. The quite blatant use of state power that allowed favored elite groups to exploit national resources further worsened environmental outcomes. In particular, by undermining respect for property rights in nationally owned natural resources, they promoted deforestation. These legacies now weigh heavily on the Philippine economy and environment.

The 1990s saw the partial dismantling of trade protection and liberalization of domestic markets, with a consequent mini-boom in aggregate growth and substantial poverty reduction prior to the Asian economic crisis. Our results, while showing only the *ceteris paribus* contribution of

[17] This result is also evident in another APEX-based study of tariff reform and industrial emissions (Coxhead and Jayasuriya, 2003a, Table 12.8).

trade policy reforms, are certainly consistent with observed trends. Trade liberalization simulations conducted under the assumption of initial slack in the labor market, reveal greater direct incentives to clear forest for timber, but lower incentives to push out the agricultural land frontier. The latter operate both directly, through relative profitability changes, and indirectly, through a reduction in poverty. Given these opposed effects in agriculture and commercial forestry, the net deforestation effect of the reforms is thus ambiguous, although the greatly diminished role of commercial timber harvesting in the past two decades suggests that on the whole the agricultural land effects are likely to have dominated.

Naturally, trade policy reform in the Philippines has been accompanied by other changes as well, some of which are policy reforms in other areas, so the net effect of these reforms on poverty and deforestation remains to be conclusively established. Our analysis reinforces the need to combine liberalized trade with appropriate government action to address market failures (open access, fiscal adjustment costs borne disproportionately by the poor) that may produce harmful environmental outcomes.

Our findings on changes in economic structure are robust with respect to substantially differing assumptions about the operation of factor markets, a particularly powerful form of structural sensitivity analysis in the general equilibrium context. The poverty and welfare results are not, however, and this suggests a fruitful line of new research to quantify the deadweight losses and tax interaction effects that must explain the differences, both to clarify these types of result and to generate input to policy discussions on poverty-minimizing policy reform packages.

Finally, some limitations imposed by simplifying assumptions in this kind of model should be noted. The geography of the Philippines, and the underdeveloped nature of roads and communications infrastructure that links remote regions to other regions and the urban centers means that inter-regional transactions and trade costs are non-trivial. These drive wedges between the prices faced by different agents even for the same goods or factors, weaken the degree of market integration, and dampen the extent to which changes in the patterns of market signals produce the assumed producer and consumer responses. The importance of such transactions costs is an empirical issue; studies in the Philippines suggest that over the medium term, agricultural markets are well integrated both at the national scale (Silvapulle and Jayasuriya, 1994) and locally within rural areas (Coxhead, Rola and Kim, 2001). Empirical evidence on internal labor migration and occupational labor mobility also indicate that an important maintained assumption of the model, that labor moves both inter-regionally and inter-sectorally, is reasonable for the medium-term. The outcomes generated by the model in these policy experiments therefore seem acceptable as reflecting at least orders of magnitude of the effects and their general direction.

The Philippine experience with trade liberalization holds several important lessons for the many developing countries that have followed a broadly similar policy trajectory. First, the higher level of poverty consequent on trade liberalization, though likely to be a short-term phenomenon, nevertheless highlights the need for well-designed safety nets

to protect the poor during the transition, and to ensure maintenance of social and political stability so that reforms are politically sustainable. Second, the nature of the environmental consequences of trade policy reforms depends critically on steps being taken to address market failures, such as property rights on forests and other natural resources. Third, the partial nature of trade liberalization – in practice almost universally the case in reforming countries – can lead to outcomes that may be both unanticipated and undesirable. The second and third cases are, of course, illustrations of the well-known theory of the second best: in the presence of other distortions, removing some distortions in the economy may not necessarily be welfare improving. More broadly, our analysis cautions against making sweeping generalizations about the impact of policy liberalization and greater integration with international markets ('globalization') on poverty-environment outcomes; as shown, implications of specific policy reform packages can be strongly context dependent and country specific.

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