Trade Liberalization, Resource Degradation and Industrial Pollution in Developing Countries

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1 Introduction

Economic growth and trade are generally said to have three types of environmental effects: scale effects, associated with increases in the overall size of the economy; technique effects due to changes in production technology; and composition effects, capturing induced changes in the structure of production and factor demand (World Bank 1992; Grossman and Krueger 1993). Of these, the first is unambiguously negative (in the sense of creating more pollution or increasing demands on depletable natural resource stocks), and the second is most likely to be positive since new technologies are by and large cleaner than old. Aggregate empirical studies of the non-linear relationship between income and pollution or demands on depletable resource stocks (the search for an ‘environmental Kuznets curve (EKC)’ as in, for example, Antweiler et al 2001) are driven by the changing relative importance of these two. But for many purposes, the greater interest is in the sign of the composition effect, about which there are no general prior hypotheses. Whereas scale and technique effects determine the shape of the EKC, changes in the structure of production—the sources of composition effects—displace it vertically, and as such may have more immediate medium-run environmental impacts.

The composition effect is of particular importance in studies of trade policy reform since the primary effects of such reform are felt through changes in relative prices, which in turn stimulate the reallocation of resources among productive activities. To the extent that different activities have varying propensities to pollute or to make use of depletable resources, changing the structure of production can have significant environmental effects. This is particularly true, of course, in developing economies with large agricultural and natural resource industries and protected heavy industrial sectors. In addition, they also alter factor rewards and income distribution, with consequences for poverty. These environmental and income distributional effects are critically affected by some of the common structural features of developing countries, such as the limited degree of spatial and sectoral factor mobility and the absence or poor enforcement of property rights over natural resources.

Because discussions of trade liberalization and its environmental and distributional outcomes evoke strong political and emotive responses, there is a premium on analytical rigor and careful drawing out of policy conclusions. The economy-wide ramifications of major policy reforms and shocks imply the need for an explicitly general equilibrium analytical approach. At the same time, it is also important to ensure that key structural and institutional features of these economies are adequately taken into consideration in analytical work. Unfortunately much theoretical work assumes overly simple economic structures to focus on an analytically interesting issue, while much empirical work either lacks rigorous theoretical underpinnings or is based on econometric results from cross-sectional country data. In both cases, they can lend support to quite misleading policy conclusions.

The recent history of economic development in a group of natural resource-rich developing market economies of Asia-Pacific (Indonesia, Malaysia, Philippines, Sri Lanka,
Thailand and increasingly, Vietnam) provide a laboratory of sorts for comparative study of development policies and that some illuminating case studies for the interaction of growth, policy reforms, trade and the environment. A half-century ago, they shared many similarities in initial resource and factor endowment and economic structure but they differ markedly today in terms of their state of development, level of industrialization and economic structure (Table 1 – to be suitably revised).

Their divergent trends in the second half of the twentieth century, as summarized by the growth rates in Table 1, can be attributed in part to differences in policy regimes. In agriculture, all countries initially taxed farm output heavily to finance industrialization (especially Thailand, a food exporter); these policies too have been relaxed, but in many cases later, and more slowly, than industrial policies. Historically, the net price-increasing effects of food import restrictions and related interventions were insufficient to offset the prevailing anti-agriculture bias of industrial promotion policies (Krueger et al 1988). In a very significant shift, however, this policy bias was inverted in the 1990s, as significant progress was made in manufacturing but not agricultural import trade liberalization. WTO trade policy rules bind import tariffs for manufactures, but are considerably more lenient where developing country agricultural imports are concerned. 2

Finally, while continuing high protection has done little to reduce production of import-competing crops, globalization and capital-deepening have also fueled massive expansion of industrial plantations. In Southeast Asia, the area planted to coffee has risen by more than 300% since 1980, while for oil palm the increase is more than 500%. 3 New land for expanding crops has been obtained primarily through the conversion of forests, where enforcement of property rights remains costly and controversial (Gérard and Ruf 2001; Vincent, Rozali and Associates 1997; Ha 2001). Deforestation rates in tropical Asia are the world’s highest (Table 2). These trends, however, mask substantial variation in country-specific conditions, and may mean quite different environmental responses to similar policy changes.

In this paper we consider the environmental and welfare effects of several types of reforms, in general, and with specific reference to some ‘representative’ developing Asian economies. The policy experiments themselves mimic, in stylized fashion, the ending of ISI policies through the relaxation of tariffs on industrial manufactures as well as the liberalization of import restrictions on food, a major issue on the current policy agenda in

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2 As a result, very high levels of protection for cereals have persisted in Asia even after major trade reforms in other sectors and rice, corn, and other staples are now among the region’s most heavily protected commodities (WTO 1998-2001). Until the mid-1990s wave of WTO accessions by developing economies, the use of QRs and other non-market barriers to restrict food imports in the name of food security (or more specifically, food self-sufficiency) was widespread in Asia (see Coxhead 2003), agricultural trade liberalization lags far behind progress — even on paper — in regional pacts such as the ASEAN Free Trade Agreement and the Free Trade Agreement of the Americas. Thus in the Philippines, for example, the effective rate of protection for manufacturing declined from 32% to 15% between 1990 and 2000, whereas that for agriculture fell only from 32% to 24% (Aldaba and Cororaton 2001). In 2000, the Philippines’ implicit tariff on rice and corn was 43% while the median value for manufactures other than food processing was under 10% (ibid.). Indonesia, another net food importer, liberalized trade in a very wide range of commodities in the 1990s but excluded rice, the main staple cereal, imports of which remain under the control of a State trading agency “to guarantee its supply to the population at affordable prices and to ensure food security” (Government of Indonesia, cited in WTO 1998).

3 FAO data reported in Coxhead (2003).
many food importing Asian developing countries. While our main focus is on policy changes and their environmental outcomes, we also consider implications for other potentially important policy concerns, such as aggregate real income and the welfare of the poor. We show that specific characteristics of the economic structure are critical for the environmental and income distributional outcomes of the major policy changes that are currently on the agenda and that simple generalizations can be quite misleading. In particular, under a variety of circumstances, both manufacturing and agricultural trade liberalization can be both pro-environment and pro-poor, but greater access to developed country markets for labour intensive manufactures of developing countries may determine whether agricultural trade liberalization will benefit the poor or not.

2 The intersectoral transmission of economic shocks

In this section we provide a geometric illustration of the main mechanisms by which a shock in one sector or region of a stylized developing economy is transmitted to others in a general equilibrium setting. The goal is to take account of key economic and spatial features of developing economies and to differentiate among types of environmental issue — primarily, between industrial emissions and deforestation at the agricultural frontier, and to highlight the direct and indirect impacts of price and policy changes and the nature of adjustments that they call forth. We begin with a base case model that captures many of the stylized facts of Asian developing economies. The formal structure of the model is presented in Appendix 1.

Trade policy, migration and environment with open-access forests

Imagine an economy comprising two sub-economies, manufacturing and agriculture. Manufacturing (M) is a H-O-S sub-economy with mobile L and K used to produce an import-competing good H, and an exportable X. The assumption that factors are intersectorally mobile tends to be a reasonable one in most manufacturing activities, at least in the medium run, but can be easily altered to allow for short run factor-specificity as an extreme case. Agriculture (A) is produced in two ‘regions’, ‘upland’ and ‘lowland’, with different land types, denoted by T in upland and N in lowland. These land type differences reflect differences in elevation, soil type, access to irrigation and other agro-climatic factors; in most Asian countries, rice, the main food staple, is grown primarily in low lying, fully or partially submerged land (that is often irrigated), while ‘uplands’ or ‘dry lands’ are cultivated to perennials - often tree crops like tea, rubber and oil palm – as well as to food crops under rain-fed conditions.4 The manufacturing sub-economy has two sectors, one with a low capital-to-labor ratio (k) and one with high k. The high k sector is import-competing and may receive protection; the low k sector is export-oriented and is not initially protected. We assume that the high k sector is also more emissions-intensive. Lowland agriculture produces food, which may be protected if this economy is a net food importer, or unprotected if it is a net exporter. Upland agriculture may also produce food (in which case the same product is produced in two spatially and technologically distinct sectors) or tree crops for export. In uplands, land is ‘produced’ by converting forests; for simplicity, we assume that the forest products themselves are of negligible value. More importantly, the forest is an open-access

4 Conversion of ‘uplands’ to ‘lowlands’ is technically feasible but costly, sometimes prohibitively so, and even when converted differences in key agro-climatic factors result in continuing productivity differences that justify treating these as essentially two different land types.
resource. Consumers value its existence, but upland farmers need not take this into account, nor spend to acquire the forest area, when making agricultural land expansion decisions. Clearing forest requires labor only. Labor is mobile among all activities: upland agriculture (and forest clearing); lowland agriculture, and manufacturing. The two manufacturing sectors also share a mobile factor, capital. Each agricultural sector uses land, assumed specific to the sector.

Commodity prices are exogenously fixed, and may differ from world market prices by measures such as tariffs, export taxes or quantitative restrictions. Tariff/tax revenues are assumed to be redistributed in lump sum fashion, and given the small country assumption, they have no impact on commodity prices. We want to know the effects of a change in some price or tax policy on production in each sector and on the returns to manufacturing capital and land in each agricultural sector. We assume constant returns to scale, perfect competition in both goods and factor markets, and complete markets for all factors except T, the land endowment in uplands. Therefore, the primary mechanism for transmittal of policy or other shocks throughout the economy is the labor market.

We can capture the main structure of the economy in Figure 1. The central panel (b) shows the usual labor market diagram, with the width of the panel denoting the economy’s total labor endowment; employment in agriculture is measured to the right from 0_A, and that in manufacturing to the left from 0_M. Labor demand curves for M and A sub-economies are constructed by horizontal addition of those for the respective sectors, as shown. In the initial equilibrium, the economy-wide wage (w) is given by the intersection of the L_A and L_M curves.

<Figure 1 about here>

In the right-hand panel (c) we show unit cost (i.e. zero profit) curves for each manufacturing sector under the assumption of constant returns to scale. This panel differs from the usual dual Lerner-Pearce diagram in that we are supposing wages to be set economy-wide rather than purely within the manufacturing sector. Product prices and the wage determine the set of feasible manufacturing industries and the location of their unit cost curves. The (negative of the) aggregate capital-labor ratio in manufacturing is shown by the line kk where an increase in this ratio increases the slope of this line, and a capital-labor ratio higher than the slope of a line tangent to c_H at the intersection of the unit cost curves (point G) implies specialization in capital-intensive production. For a given wage, we can read off the equilibrium return to M sector capital, r_M, on the horizontal axis.

In the left-hand panel (a) we show the analogous curves for the two agricultural sectors. The horizontal axis shows unit returns to land in each agricultural region, r_U and r_F. These are not required to be equal, though for convenience we have chosen units of land so as to equate them in the initial equilibrium.

Absence of property rights in upland land means that profit-maximizing upland producers use upland land up to the point at which its average product is equal to average cost (Gordon 1954). We can capture this in the figure, by interpreting the curve L_A in panel (b) as the horizontal sum of labor demands in lowland and upland agriculture, noting that

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5 Output in each of the M sectors can also be computed from the diagram, by drawing lines tangential to each unit cost curve at the point of intersection and calculating sectoral employment shares of capital and labor along each axis. See Mussa (1979).
under open access to forests, upland labor demand exceeds the quantity that would be observed if property rights were enforced. In the initial equilibrium, open access means that there is overuse of labor in upland; were property rights enforced, the total labor demand curve in agriculture would lie to the left of $L_A$.

In manufacturing, we assume that producers in the dirty industry are not penalized for emissions — another form of property rights failure, this time for clean air and water. Unlike the case of forest, however, ‘free disposal’ of air and water pollutants leaves producers on their marginal curves, producing a pure externality.

Policy shocks and outcomes
How do factor prices and the structure of production respond to a change in some policy or product price? To see the working of the model, let the price of the labor-intensive manufacture, $p^X$, be a numéraire, and consider an increase in the price upland agriculture, $p^U$. As shown in Figure 2, this displaces the demand for upland labor vertically upwards in panel (b) by the amount of the price rise, and the aggregate agricultural labor demand curve is displaced vertically by the price change times the upland share of agricultural labor. With no change in manufacturing prices, the aggregate labor market response is clear: labor is withdrawn from manufacturing and into agriculture; within agriculture, it is reallocated from lowland to upland production.

As a result of the price change, production in upland rises and that in lowland falls. For the lowland, where the quantity of land is fixed, the output change can be read directly from the horizontal axis in panel (b); it is proportional to the reduction in labor use at the new, higher wage. For the upland sector, we suppose that new land may be brought into production; however, as long as the labor required to convert forest is directly proportional to that required for upland production, the change is still proportional to the labor demand shift. Returns to land in each agricultural region are altered, as seen in panel (a); that in upland rises and that in lowland must fall.

At the original wage and price levels, the withdrawal of labor from M has predictable Rybczinski effects, i.e. there is a lowering of the aggregate $K/L$ in manufacturing (in terms of Fig. 1, the line $kk'/bb'$ becomes steeper) and the labor-intensive sector (X) contracts while H expands. As long as the quantity of labor withdrawn is relatively small, the manufacturing economy remains within its original cone of diversification with the return to capital unchanged at $r^0_M$.

This is not an equilibrium, however, as the increase in agricultural labor demand also exerts upward pressure on the wage. With constant output prices, the productivity of labor in M must rise to match the wage increase. As a consequence of the wage increase the M sector’s aggregate labor demand falls and the $L_M$ curve in panel (b) moves to the right. The final labor market equilibrium, depending on the extent to which the M industries in aggregate release additional labor, will be an economy-wide labor allocation lying between $L^1$ and $L^2$, with a wage between $w^0$ and $w^1$. In manufacturing, both the quantity and price effects of the economy-wide labor market adjustment will reduce the output of the labor-
intensive sector; the output of the capital-intensive sector may rise or fall. The return on M sector capital must also fall.

The environmental effects of the agricultural price increase can be inferred from the adjustments shown in the diagram. In manufacturing, we assume that the capital-intensive sector pollutes while the labor-intensive sector does not. The ‘dirty’ H sector has expanded relative to the ‘clean’ X sector, so the overall emissions-intensity of manufacturing has risen. Whether total emissions rise or fall depends on whether the dirty sector has expanded output in absolute terms, or not. In agriculture, we assume lowland production to be ‘clean’ while upland production makes use of open-access forest to generate land. The price rise for upland agriculture increases the demand for land, thus raising the return to labor used in clearing forest as well. Moreover, the release of some labor from manufacturing reduces costs in upland production and forest clearing, thus further increasing the deforestation response. Looking across the economy as a whole, the price rise is an environmental lose-lose proposition (more deforestation, more emissions) if H expands, or a lose-win proposition if H contracts.

Changing tariffs on ISI sectors
Other variations on Figure 1 can be used to consider other price and policy changes. One is the effects of a fall in the price of H, due, for example, to the relaxation of tariffs as ISI policies favoring heavy industry are abandoned. In many respects this is just the reverse of the story just told. At constant wages, the tariff reduction displaces $c_n$ inwards, so the new intersection of unit cost curves is above and to the left of G. At the lower tariff rate, X sector output expands and H contracts. At the original wage level, the M sector will increase its labor demand overall; this will in turn bid up the economy-wide wage and reduce profits in all agricultural activities, including land-clearing. The environmental outcomes associated with the tariff reform are clear and unambiguous: manufacturing becomes less emissions-intensive as the dirty industry contracts, and there is less deforestation due to the higher cost of land-clearing. Reducing the tariff is an environmental win-win policy move, even with open access forests.

Changing protection for food producers
In a third experiment, consider the situation in which food producers are initially protected from import competition; the scenario that is of relevance to many developing countries now looking at agricultural trade liberalization.

If food is produced in lowland only, then relaxing barriers to food imports will have mixed effects. An inward shift of the lowland unit cost curve in panel (a) of the figures, and the corresponding downward displacement of the $L_F$ and $L_A$ curves in panel (b), will reduce the wage, lowering costs in other sectors. Deforestation in upland will expand, while in manufacturing there will be positive Rybczinski effects reinforced by the falling wage; the labor-intensive X sector will expand while H may expand or contract. The overall environmental outcome is thus mixed: more land-clearing in upland, while the M sector as a whole becomes less emissions-intensive (and emissions may even fall absolutely).

For many countries, however, it is more appropriate to think of food as produced in both agricultural regions (for example, irrigated rice in lowland and rainfed rice or corn in upland has been a common in farming systems of the Philippines). Under this assumption, a lower food price displaces $L_A$ down by the amount of the price change and shifts both $c_F$ and
cU in toward 0." Lowering import barriers on food will then have a direct pro-forest effect by reducing incentives to expand agricultural land, but at the same time will further lower the cost of land-clearing, thus indirectly contributing to more deforestation. Whether deforestation will rise or fall on balance will depend significantly on the extent to which manufacturing sectors take up extra labor as product wages fall. The presence of a large, very labor-intensive X sector increases the chances that reducing the protection on food will not have a large land-clearing effect; conversely, if food policy is relaxed in an economy with mainly capital-intensive ISI manufacturing, the wage-driven decline in land-clearing costs will be correspondingly higher. In a nutshell, the environmental consequences of the food policy change will depend on initial economic structure.

An important side-effect of both food policy scenarios is that while the real wage must rise (since labor absorption in non-food sectors restricts the drop in the wage to less than that of the food price), the real incomes of some groups in the economy may fall. In particular, rural households who derive income from labor and land may experience increased poverty if losses from declining land returns outweigh their gains from higher wages and cheaper food. This presents a policy dilemma that is familiar to students of large, poor, agrarian Asian economies undergoing or contemplating agricultural trade liberalization. Our analysis stresses the importance of economy-wide labor market adjustments to poverty outcomes, with the clear implication that policy reform packages, rather than piecemeal efforts at sectoral level, may be the key to simultaneous poverty reduction and environmental improvement.

Reform of property rights
Finally, recall from the discussion of Figure 1 that because there is open access to forests for conversion to upland land, the privately optimal labor allocation in upland agriculture equates average, rather than marginal costs and returns. Thus the curve L_A in panel (b) of the figure is equal to the horizontal sum of labor’s value marginal product in lowland agriculture and its average product in upland. It follows that enforcing property rights in forests, which reduces the rents earned from land-clearing, displaces the L_A curve to the left -- in the limiting case, to the point at which it is simply the sum of the upland and lowland marginal (i.e. labor demand) curves, and property rights in forest are fully enforced. In panel (c), an increased labor endowment and lower economy-wide wage will once more reduce the overall emissions-intensity of manufacturing production, and — if these effects are large enough that H output contracts absolutely — even reduce it in absolute terms.

It is now clear that other things equal, enforcement of forest property rights will hurt the poor disproportionately. Not only do upland farmers, typically the poorest group in any developing country population, lose rents formerly earned on ‘free’ land, but the economy-wide wage decline associated with restricting access to upland will potentially hurt all wage-earners. Enforcing property rights in upland land amounts to the reversal of internal migration policies, widely adopted in insular Southeast Asia beginning in the 1950s, in which governments subsidized the movement of poor landless families to the agricultural frontier, where their labor productivity could be enhanced by access to supposedly abundant forest-covered lands. If governments are to pursue environmental protection simultaneously with poverty alleviation, the declaration of protected forest areas and other legal and institutional innovations restricting the growth of upland agriculture will have to be accompanied by policies that increase labor productivity elsewhere in the economy. ISI policies, where they
persist, are obvious candidates for relaxation to achieve growth with environmental protection and poverty alleviation. Reducing protectionist policies for lowland (food) agriculture may, in contrast, have the opposite effect.

The analysis so far has explored direct and indirect effects of sectoral interventions when major component parts of the economy are linked by an integrated labor market. Through both price and quantity changes, labor market adjustments to a sector-specific price or policy shock convey cost signals to producers in other sectors or regions. In manufacturing, the standard Rybczinski effects associated with labor endowment changes in a Heckscher-Ohlin-Samuelson economy are augmented by economy-wide wage adjustments. On the environmental front, wage and labor force changes may alter incentives to deforest (labors may migrate to or away from the frontier) and to engage in relatively capital-intensive ‘dirty’ manufacturing production. These effects may be accompanied by changes in real incomes, potentially raising additional challenges when poverty alleviation is a policy target.

3. Economic structure and Environment: some stylized Asian economies

3.1 Protection and the environment in the “jeepney” economy

The model outlined above is capable of a number of permutations, each reflecting a different economic structure and set of policies. One is the case of an economy producing food in both agricultural regions, in addition to the two types of manufacturing industry, capital-intensive ISI and labor-intensive exportables. This configuration is a stylization of many developing Asian economies prior to the recent era of globalization, and in honor of the Philippine economy prior to liberalization in the Ramos era (1992-1998) we call this the “jeepney” economy.

Consider a tariff on capital-intensive manufactures in the jeepney economy. With other product prices fixed, this increases the relative profitability of ISI production, and labor and capital are transferred to the protected sector; its output goes up, and the manufacturing sector as a whole becomes more emissions-intensive. Within manufacturing, however, the tariff raises the return to capital and lowers that to labor in the usual Stolper-Samuelson fashion. With a constant food price, labor is drawn into agriculture with lower wages. The cost of land-clearing for upland agriculture falls, so the tariff also increases deforestation.

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6 The model and analysis in this section is a substantive variation on that in Coxhead and Jayasuriya (2003). Some of its features, notably the modeling of forest clearing in upland, are drawn from Lopez and Niklitschek (1991).
7 Coxhead and Jayasuriya (2003) explore intersectoral production externalities in a similar model.
8 This rather stark assumption is made for convenience only, and an extension to the model could provide for labor-land substitution in upland. In other work (Coxhead and Jayasuriya 2003) we permit such substitution by modeling upland production with more than one output and different factor proportions.
9 If there were non-traded final goods in the economy, there would be additional substitution terms in (6) due to endogenous price changes. We explore these in Coxhead and Jayasuriya (2003, Chapter 4).
10 In a comparable model, Copeland (1994) addresses the modeling of tariffs versus quotas in the presence of environmental externalities.
11 Cast in this way, the experiment may also be interpreted as conveying a world market shock, such as from the award of food production incentives in a large trading partner.
12 As can be inferred from Figure 1, a lower p' also implies a lower wage, which on its own increases labor demand in the food sector. However the wage decline, being a second-order effect, is unlikely under reasonable parameter values to more than offset the direct labor demand effect of the price fall; hence we presume dL < 0.
13 FAO data reported in Coxhead (2003).
pressures. Net migration of labor into uplands, as a response to declining productivity and earnings potential in manufacturing, is a well-documented feature of ISI regimes (e.g. Cruz et al 1993); the tariff is one factor giving rise to the increased population pressure on upland resources that is often identified as a cause of deforestation.

Second, consider agricultural protectionism, for example that motivated by concerns about food self-sufficiency as a source of food security. Higher food sector protection draws labor out of manufacturing, and the Rybczinski theorem tells us that the manufacturing industry experiencing the largest relative output decline will be the labor-intensive, export-oriented one. Both upland and lowland agriculture will expand. Lowland, however, is constrained by a fixed land endowment; in uplands, the higher food price increases the return to forest clearing to create new lands. In Asia, high and increasing rates of protection for corn and other cereals grown largely in uplands and non-irrigated areas has been associated with agricultural expansion at the forest margin (Coxhead, Shively and Shuai 2002; Coxhead 2000). Thus the protection for food producers increases deforestation and reduces the output of labor-intensive manufactures. The emissions-intensity of manufactures rises, but overall industrial pollution may rise or fall since the sector as a whole will contract.

The combination of industrial protection and agricultural protection in the jeepney economy thus favors both emissions-intensive industrial development and deforestation at the upland agricultural margin. Whether total industrial emissions are higher or lower relative to free trade depends on parameter values.

The “becak” economy
The becak is a tricycle rickshaw once common in Indonesia, and the becak economy is so named because it has characteristics representative of that country’s economic structure. In stylized form, it differs from the jeepney economy only in that upland agriculture produces treecrops for export rather than food. As in the earlier case, the land frontier is open in the sense that forest can be freely converted to fuel agricultural expansion, in spite of negative externalities generated by forest clearing. Such negative externalities with transboundary dimensions are particularly pertinent in the Indonesian case, where widespread forest burning to establish oil palm and other plantations since the late 1990s has generated significant pollution in the form of smoke, or ‘haze’ through much of Indonesia as well as many other neighboring countries of (Schweltheim and Glover 1999).

With tree crops exportable, manufacturing protection again releases labor to both agricultural sectors. The rate of expansion at the frontier depends on tree-cutting technology (in a more sophisticated model, it would matter whether the forests had previously been logged, and thus made more readily accessible to colonizing farmers; see Angelsen 1995). Protection for food producers, in the becak economy, causes the lowland region to expand, raising labor demand; this promotes downslope migration and discourages deforestation at the upland frontier. As before, the protection for food producers also draws labor out of the manufacturing sector, reducing the relative size of the exportable goods sector and increasing emissions-intensity. By comparison with the jeepney economy, in the becak economy agricultural protectionism tends to diminish pressures on forests.

The “tuk-tuk” and “cyclo” economies
Another interesting case is that in which food is exported rather than import-competing. This is the case with Thailand and, more recently, Vietnam. In Thailand, food is produced in both
agricultural regions; in Vietnam it is produced primarily in lowland only, with plantation crops occupying the uplands and the forest margin. Continuing the transport metaphor, we can think of these variants as the ‘tuk-tuk’ and ‘cyclo’ economies respectively.

In the both economies, industrial protectionism has the same effects as already described. Additions to the labor force must find employment in agriculture rather than industry, and with an open land frontier, engage in deforestation. This process ended in Thailand in the 1990s, after several decades of unfettered harvesting of forests both for timber and agricultural land, during which time forest cover diminished dramatically. In Vietnam, ‘push’ migration of this kind was apparent in the 1980s and early 1990s, although it is more likely a failure of industrial growth, rather than protection for non-labor intensive sectors, that was the prime mover.

In both economies, trade and related policy reforms have seen huge increases in manufacturing sector activity, especially in the most labor-intensive industries. In the Thai case this has been accompanied by extraordinary rates of outmigration from the countryside, and especially from the forest frontier areas, with the total agricultural area diminishing by more than 10% between 1989 and 1996 (Coxhead and Jiraporn 1999). In Vietnam, however, the opening of the economy has caused a land race at the forest frontier. Between 1989 and 2000, Vietnam’s harvested coffee area increased by a factor of more than one hundred, from 42,000 ha to 477,000 ha\(^{14}\) as the country became the world’s second-largest coffee exporter, and other crops such as mulberry and tea have also experienced rapid area growth (Ha 2001).

These sketches, although obviously quite incomplete, nevertheless provide indicators of some of the ways in which apparently minor variations in economic structure can be associated with very substantial differences in the ways in which apparently similar policy reforms influence the use of environmental and natural resources. If nothing else, they do indicate clearly that even within a relatively homogeneous subset of developing resource-rich economies, there are no grounds for supposing the existence of a common set of environmental and natural resource depletion trends in the course of economic growth. Reading further between the lines, they also suggest some tentative conclusions concerning development with incomplete property rights in natural resources. Open access to forest is a more severe problem when other labor-intensive sectors in the economy fail to grow. In the language of the EKC literature, a capital-intensive industrialization strategy may induce composition effects that displace upward its EKC, not only for industrial emissions, but also for deforestation. Pro-environment development strategies inherently address more than one target, and as such must involve more than one instrument.

5 Some concluding remarks

Debate on the environmental effects of trade liberalization in developing countries continues to grow in intensity, but theorizing on the underlying economics lags behind the empirical literature. The analytical model in this paper is a useful tool for understanding the general equilibrium sources and consequences of policy changes. These can have intersectoral effects, of a sign and a magnitude determined by the initial structure of the economy being examined, and importantly, the same shock could well have opposed environmental effects in two different economic types. This finding undermines analyses of the trade-growth-environment relationship that rely on uniform assumptions about economic structure in

different economies. A second finding is that different types of environmental damage— in our example, industrial emissions and deforestation— respond differently to economic shocks. A third point is that when environmental externalities coexist with policy-induced distortions, partial policy liberalization may have negative effects on aggregate welfare on other environmental problems, or on indicators of poverty.

None of these findings is new in the trade literature, but they have yet to emerge as clearly understood facets of the analysis of economy-environment relationships in developing economies. But, these analytical results can play an important role in highlighting the lack of generality of conclusions reached in papers in the trade-environment literature (such as that of Deacon (1995)) that provide support for those who argue that trade liberalization is likely to be anti-environment. As we have shown, allowing moving away from a pure specific factor model is sufficient to generate results that immediately undermine the generality of the trade liberalization- anti-environment relationship.

Any further extension of the model to bring it closer to the empirical reality of developing countries introduces new sources of ambiguity about the trade-environment relationship. Consider, for example, the case in which agriculture in either or both regions consists of two distinct sectors, cash crops and subsistence crops. Cash crops are grown for export as well as domestic consumption. Subsistence crops are grown only for the home market: thus, even in a small open economy, the prices of subsistence crops depend on domestic demand and supply. Suppose further that subsistence crops compete directly with forest land (a common example is the case in which rice, sugar and other internationally traded crops are grown in irrigated lowlands, while coarse grains and vegetables for the home market are grown mainly in uplands, at the forest margin). In this scenario, trade liberalization lowers the relative price of manufactures, and this raises the real wage as predicted by Stolper-Samuelson. The output price effect on its own causes both agricultural sectors to expand. However, the higher wage has differential effects within agriculture. If the subsistence crop sector is labor-intensive relative to cash crops (as is often the case in developing economies), then costs in that sector rise by more than costs in cash crops. So long as the demand for subsistence crops is relatively inelastic with respect to incomes, the net effect of trade liberalization is a contraction of the subsistence sector. Since this is the sector that competes with forestry for land, deforestation is reduced.

Of course, a different set of assumptions about sectoral factor intensity might generate the opposite result. Our point is that the effects of trade liberalization on deforestation must be evaluated on a case-by-case basis. While the appeal of simple and elegant models (of the type presented by Deacon, for example) is beyond dispute, in the highly charged atmosphere of current debates on trade and the environment it should be emphasized the impact of trade policy on deforestation will vary greatly with the specific circumstances of individual countries.

We conclude with some remarks on the EKC. A great deal of energy has been expended on the so-called theoretical underpinnings of this relationship (for example, Andreoni and Levinson 1998) and on empirical exercises purporting to test for its existence (for a recent survey see Anriquez 2002). The very concept of an EKC is problematic: it inevitably refers to trends in the emissions of a single pollutant or the depletion of a single natural resource stock, there being no meaningful index of ‘environment’. More fundamentally, however, the modeling in this paper underscores the argument that the EKC is a concept with almost no usable normative or policy content. Theoretical EKC models
invariably abstract from the composition effect that has been the main focus of our study. Empirical analyses nearly all rely on cross-country data, using models that reduce country-specific market, policy and institutional features to mere caricatures at best. Our approach, by contrast, directly identifies the economic, institutional and policy determinants of changes in individual measures of resource depletion or environmental quality. It does so in a general way that explicitly recognizes potential inter-country differences in economic structure, policies and institutional arrangements. More than this, it identifies the indirect, intersectoral determinants of environmental change, their interactions with conventional indicators of economic well-being, and provides a road-map (albeit a large-scale one) for empirical and policy-oriented research at the country level.

In spite of our claim to relatively greater generality, the model we have presented merits extension in a number of areas. Foremost among these is to examine effects of the other major feature of globalization, the opening of economies to international capital flows. As a first step in this direction, the model in section 3 permits derivation of implied changes in rates of return to capital in manufacturing and (with some minor elaborations) in each agricultural region. The implications of policy changes for investment incentives by sector and region can thus be derived, opening the way to a longer-run analysis in which net international capital flows by sector and region alter the environmental and welfare outcomes we have described. This will be an important extension if we are to consider empirical phenomena with substantive environmental implications, such as the rapid expansion of Indonesia’s oil palm industry. A second relatively easy extension is to relax the assumption of a unified, flexible-wage labor market. Transactions costs and institutional barriers to wage adjustment are characteristic of many developing economies, as is persistent (equilibrium) unemployment. Amending the model to include these features, as in Corden and Findlay’s (1975) restatement of the Harris-Todaro migration model, is fairly straightforward as an inspection of Figures 1 and 2 makes clear. Finally, bringing in non-traded goods in explicit fashion will add complexity and realism, although at some cost in terms of the clarity of exposition. These three subjects are the focus of our ongoing research in this area.
Appendix A.1 General equilibrium analysis

The analysis so far has captured what is arguably the primary mechanism for intersectoral transfer of shocks, the labor market. In this section we present a more complete general equilibrium model, one taking account of the requirement that aggregate expenditures and income be equal in equilibrium (and thus, by Walras’ Law, ensuring that the current account is also in balance). For this analysis we introduce the model in algebraic form, using the trade expenditure function (Dixit and Norman 1980; Lloyd and Schweinberger 1988). This enables us to evaluate reforms for their effects not only on the environment but also on a measure of consumer welfare. We retain a comparative static approach, while recognizing that under some circumstances the transitional dynamics of adjustment to a shock may produce somewhat different outcomes.

The structure of the model is similar to that developed in section 2. Since labor is the only factor mobile among all sectors, for analytical purposes manufacturing is a separate H-O-S economy, but with both its labor endowment and wage determined by an economy-wide labor market equilibrium condition. For a given quantity of labor in manufacturing, the two agricultural sectors, each with specific land and mobile labor, are like a Ricardo-Viner-Jones specific-factors economy. With the help of these analytical constructs we can evaluate the impacts of price and policy shocks as well as the direction of changes in environmental and natural resource depletion externalities. As before, we make the simplifying assumption that environmental damages affect the economy only through consumer preferences rather than through intersectoral effects on production costs.

The economy consists of producers making resource allocation decisions in a competitive market environment, with the exceptions that as before, the forest resource may be freely depleted to create upland land, and factories in the ‘dirty’ manufacturing industry (H) may emit pollution without penalty. Following Lopez and Niklitschek 1991, we suppose that each unit of upland land, T, is cleared from forest using the input of a constant quantity of labour; thus $T = T_L$. Industrial emissions, J, are produced in constant proportion to the output of H, i.e. $J = y_H$, $y > 0$. We assume an initial policy distortion in the form of a tariff on imports of the output produced in the dirty industry. All industries compete for a common (and exogenously fixed) pool of labor, $L = L^U + L^F + L^M$. Prices (assumed exogenous) for each good are $p^U$ and $p^F$ for upland and lowland agriculture respectively, and $p^H$ and $p^X$ respectively for the import-competing (dirty) and exportable (clean) manufactures. By the choice of a numéraire, $p^X = 1$. The quantities of lowland land, N, and manufacturing capital, K, are assumed exogenously fixed. Using this notation we define revenue functions for each sector or region:

Lowland (food): $Q(L^F, N, p^F)$
Upland: $R(L^U - T, T, p^U)$

---

15 The model and analysis in this section is a substantive variation on that in Coxhead and Jayasuriya (2003). Some of its features, notably the modeling of forest clearing in upland, are drawn from Lopez and Niklitschek (1991).

16 Coxhead and Jayasuriya (2003) explore intersectoral production externalities in a similar model.
The functions Q, R and S each give the maximum revenue earned by sectoral or regional producers for given prices, technologies and factor endowments. These functions are non-decreasing and homogeneous of degree 1 in prices and endowments. By the envelope theorem their partial derivatives with respect to prices are sectoral outputs, and partial derivatives with respect to factor endowments are shadow factor prices. We now write income from production as the sum of sectoral and regional revenues:

\[ I = Q(L^F, N, p^F) + R(L^U - \bar{T}, T, p^U) + S(L - L^F - L^U, K, p^H) \]  

(1)

Sectoral outputs and factor prices are obtained by the envelope theorem, from the output price and factor quantity derivatives of the sectoral and regional revenue functions.

Consumer preferences and behavior are captured by a conventional conditional expenditure function, in which the quantities of industrial emissions J, and the amount of standing forest cleared for agriculture, T, enter as exogenous quantities:

\[ E = E(p, J, T, \bar{\square}) \]  

(2)

where \( p \) is the vector \( (p^F, p^U, p^H, 1) \). This embodies all the information on the preferences of a utility-maximizing representative consumer with utility function \( \square(F, U, H, X; J, T) \), with \( \bar{\square}_F > 0, \bar{\square}_U > 0, \bar{\square}_H > 0, \bar{\square}_X > 0, \bar{\square} \leq 0, \bar{\square}_T \leq 0 \). To simplify the analysis we have assumed that utility is separable between marketed goods and environmental bads.

As a notational convention we write the derivatives of Q, R, S and E with respect to prices using the symbols for each sector, e.g., \( E_u = \partial E/\partial p^U, E_{HF} = \partial E/\partial p^H \partial p^F \), and so on; derivatives with respect to factors are written (for example) \( R_L = \partial R/\partial T \). By the properties of the revenue and expenditure functions and the envelope theorem, \( R_L \) is the supply of upland output, \( Q_u \) is the shadow value of lowland, \( E_H \) is domestic demand for import-competing manufactures, \( E_t \) is the negative of willingness to pay for standing forest, \( E_T \) is the reciprocal of the marginal utility of income, and so on. Finally we introduce a single policy measure. The initial domestic price of H is increased by a tariff, given by \( t_H = p^H - \bar{p}^H \), where the bar indicates a world price in domestic currency terms.

Given the optimizing behavior represented by the revenue and expenditure functions, the aggregate budget constraint of this economy, with tariff income equal to the tariff rate multiplied by excess domestic demand for H, is:

\[ E = I + t_H(E_H - S_H) \]  

(3)

There is full employment in equilibrium, so the usual marginal productivity condition for labor requires that the following conditions hold:

\[ Q_L = R_L \]  

(4)

\[ R_L = S_L \]  

(5)

and

\[ R_T - \bar{\square}R_L = 0 \]  

(6)
The latter condition (6) ensures that in the upland sector, labor used in land-clearing and in production are of equal value at the margin. It is thus a property of the model that since labor is the only input to land clearing, any shock that raises labor productivity in upland production also generates pressures for deforestation.\footnote{This rather stark assumption is made for convenience only, and an extension to the model could provide for labor-land substitution in upland. In other work (Coxhead and Jayasuriya 2003) we permit such substitution by modeling upland production with more than one output and different factor proportions.} The solution to equations (3)–(6) yields equilibrium values of real income, $L^L$, $L^U$, and $T$, each as a function of $(p, t^H, L, N, K)$; from these we can calculate changes in $L^M$ as well as sectoral and regional outputs, the wage, and industrial emissions.

In the remainder of this section we use this model to explore the general equilibrium effects of some price and policy changes. For clarity, and to conserve space, we do not provide complete comparative static solutions (Appendix A.2 sketches the procedure, and see Coxhead and Jayasuriya (2003) for complete solutions to an analogous model). The results presented below rely mainly on differentiation of (3), and are largely sufficient to indicate the nature of each complete solution.

Effects of a tariff change

The real income effect of a small increase in the tariff is found by totally differentiating (3), using (2) and (1) and setting changes in the exogenous prices and quantities, $L$, $K$, $N$, $p^U$, and $p^F$, equal to zero. Defining net imports $Z_{it} = (E_{it} - S_{it})$, and using (4) and (5) to eliminate some terms, we obtain:

$$\begin{align*}
\frac{\partial \Pi}{\partial t} + E_t dJ + E_t dT &= t^H Z_{it} dt^H - t^H S_{it} dL^M \\
\end{align*}$$

(7)

where $\frac{\partial \Pi}{\partial t} = E_t - t^H E_{it} > 0$ and $dL^M = -(dL^F + dL^U)$. The first term on the left hand side provides a measure of change in the real income of the representative consumer; the second and third terms capture the utility effects of changes in each of the environmental variables. If we ignore environmental damages for a moment by setting $E_j = E_t = 0$, then (7) yields a measure of the change in real income due to the tariff rise. The first term on the right hand side is the familiar deadweight loss due to a reallocation of resources within the manufacturing sector as a whole; it is negative as $Z_{ih} = (E_{ih} - S_{ih}) < 0$. The second term captures an additional efficiency loss due to the reallocation of labor from agriculture to manufacturing. This term is negative, depending on whether the tariff causes labor to flow into or out of the M sector as a whole. Converting the relevant parts of (7) to proportional changes rather than the absolute changes shown (see Appendix A) yields an expression in which we see that the magnitude of the environmental and welfare changes due to the tariff depend on the magnitude of the H sector in relation to overall income and expenditures, the tariff as a percentage of $p^H$, the capital-intensity of the H sector relative to manufacturing as a whole, the elasticities of domestic excess demand for H with respect to own price, and the elasticity of the economy-wide wage with respect to $p^H$.

Now consider the environmental terms on the left hand side of (7). If, as we have assumed, H is the only polluting industry in M, then emissions J must increase with the tariff, and any gain (or loss) in consumer welfare from consumption of marketed goods is augmented by additional losses due to increased consumption of emissions. Whether the tariff causes deforestation to increase or decline (and thus T to fall or rise) depends, in this
model, on whether there is a net labor inflow or outflow to upland agriculture – as was demonstrated in section 2.18 Thus deforestation impacts depend on the tariff and on the characteristics of the sector(s) to which it is applied, even if these are spatially distant from the frontier and linked to upland production only in indirect fashion.

Food policy reforms
Suppose now that the economy is a net food importer, and that in addition to the tariff there is an initial food policy intervention that limits import competition. In keeping with widespread developing-country conditions prior to the mid-1990s, we may suppose that the food policy is a quantitative restriction rather than a tariff; this simplifies the algebra without relinquishing substantive explanatory power.19 Relaxing the policy implies a drop in domestic food prices, and we take this as our comparative static experiment.20 The comparative statics deal first with food production in lowlands only, although a variant in which both upland and lowland are devoted to food production is also of empirical interest. Returning to equation (3), take the total differential with respect to \( p^F \), holding the tariff, factor endowments and other product prices constant:

\[
\delta H + E_F dJ + E_T dT = -(Z_F - t^H Z_{HF}) dp^F + t^H S_{HL} dL^F
\]  
(8)

The price reduction naturally reduces labor demand in food production, so even without an explicit solution it is clear that \( dL^F < 0 \).21 The first expression on the right hand side of (8) has a direct positive effect since \( Z_F > 0 \) (domestic food demand exceeds domestic supply), and an indirect negative effect through substitution between food and ISI manufactures. The second term captures labor market adjustment; \( S_{HL} < 0 \) by the capital-intensity of H within manufacturing, so for \( dL^F < 0 \), this term is also positive. Reducing the price of food, an importable, is likely to increase real income. Naturally, the output of the lowland sector, \( y^F = Q_y(L^F, N, p^F) \), must fall, as must the economy-wide wage.

The food price decline having released labor and lowered wages, the manufacturing sector will see an expansion of labor-intensive production through both Rybczinski (constant-wage) and wage effects. The output of H will decline, and industrial emissions will fall (\( dJ < 0 \)), conferring an additional benefit on consumers. In upland, however, the lower wage will reduce land-clearing costs; labor will migrate to the frontier and deforestation will increase.

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18 If there were non-traded final goods in the economy, there would be additional substitution terms in (6) due to endogenous price changes. We explore these in Coxhead and Jayasuriya (2003, Chapter 4).
19 In a comparable model, Copeland (1994) addresses the modeling of tariffs versus quotas in the presence of environmental externalities.
20 Cast in this way, the experiment may also be interpreted as conveying a world market shock, such as from the award of food production incentives in a large trading partner.
21 As can be inferred from Figure 1, a lower \( p^F \) also implies a lower wage, which on its own increases labor demand in the food sector. However the wage decline, being a second-order effect, is unlikely under reasonable parameter values to more than offset the direct labor demand effect of the price fall; hence we presume \( dL^F < 0 \).
If food is produced in both upland and lowland areas, we have \( p^U = p^F \). Repeating the food price experiment has broadly similar results, except that now the incentive to clear forests for upland land is absent. Wages fall by more than in the previous case, but whether by enough to causes deforestation to increase is not known.

**A.2 A sketch of the general equilibrium solution to equations (3)–(6)**

The system of equations in (3) to (6) captures the equilibrium of the economy when the aggregate budget constraint is satisfied and the labor market clears across all regions and sectors and activities. To keep notation compact, write equation (3) in the form:

\[
A(\mathcal{I}, L^F, L^U, T \mid p, L, N, K, t^H) = 0,
\]

and similarly, write (4), (5) and (6) as:

\[
B(\mathcal{I}, L^F, L^U, T \mid p, L, N, K, t^H) = 0,
\]

\[
C(\mathcal{I}, L^F, L^U, T \mid p, L, N, K, t^H) = 0,
\]

\[
D(\mathcal{I}, L^F, L^U, T \mid p, L, N, K, t^H) = 0.
\]

Take the total differential of these expression with respect to any exogenous variable \( \mathcal{I} \) (\( p, L, N, K, t^H \)), holding the other exogenous variables constant at their initial values. This gives:

\[
\begin{bmatrix}
A & A^L_F & A^L_U & A^T \\
0 & B^L_F & B^L_U & B^T \\
0 & C^L_F & C^L_U & C^T \\
0 & D^L_F & D^L_U & D^T
\end{bmatrix}
\begin{bmatrix}
d\mathcal{I} \\
dL^F \\
dL^U \\
dT
\end{bmatrix}
= \begin{bmatrix}
0_A \\
0_B \\
0_C \\
0_D
\end{bmatrix}
\]

from which we obtain the general equilibrium solutions \( d\mathcal{I}(\mathcal{I}) \), \( dL^F(\mathcal{I}) \), \( dL^U(\mathcal{I}) \), and \( dT(\mathcal{I}) \).

**A.3 Derivation of equation (7) in elasticity form**

Ignoring the two environmental terms on the left hand side, equation (7) relates changes in consumer real income directly to changes in the tariff, and indirectly to intersectoral labor flows induced by the tariff change. The direct term is negative; the indirect term is of indeterminate sign. The magnitudes of both are of interest when we consider the tariff experiment across economies with different initial structure (relative size of sectors, etc). Converting from absolute to relative changes of variables yields expressions whose parameters are readily given economic interpretation. Taking the direct tariff term first, we have

\[
t^H Z_{\mathcal{I}t} dt^H = t^H \frac{\partial Z_{\mathcal{I}p}}{\partial p} dt^H
\]

\[
= t^H : \mathcal{I}^H \cdot \frac{Z_{\mathcal{I}p}}{p^H} dt^H,
\]
where $[H]$ is the elasticity of excess demand for H w.r.t. own price. Dividing (7) by initial total expenditure E gives, for the direct tariff term:

$$\frac{[H]}{E} \cdot Z \cdot \frac{t}{p} \cdot dt,$$

which is the elasticity of excess demand ($< 0$) times excess demand as a fraction of total expenditures, times the tariff as a fraction of domestic price, times the tariff change. The direct tariff effect will be larger, the greater in absolute value is each of these terms.

The indirect term can be similarly reinterpreted:

$$t[H]S[H]dL^M = t[H] \frac{\partial S[H]}{\partial L^M} dL^M,$$

then using Hotelling’s lemma to obtain $S[H] = y[H]$, the output of sector H, and Young's theorem (symmetry of second partial derivatives), we have:

$$t[H] \frac{\partial y[H]}{\partial L^M} dL^M = t[H] \frac{\partial w}{\partial p[H]} dL^M,$$

or, after dividing through by E and some minor manipulation,

$$\frac{t[H]}{p[H]} \frac{[L]^H}{E} \cdot \frac{w[L]^H}{L^M} \cdot \frac{dL^M}{L^M},$$

where $[L]^H < 0$ is the elasticity of the wage with respect to $p[H]$, and $[L,H]$ is the share of H sector in total manufacturing employment. The sign of $dL^M/L^M$ is determined in general equilibrium by the simultaneous solution to equations (3)–(6), and will depend on the relative magnitudes of the tariff-induced changes in relative prices and wages. If $dL^M/L^M > 0$, the migration of additional labor into manufacturing as the result of the tariff exacerbates the existing misallocation of resources in the economy, and thus further reduces real income. Expression (A.2) says that the welfare loss from labor transfers due to the tariff is greater, the higher is the tariff in relation to domestic price, the greater is the (absolute value of the) wage elasticity, and the larger is the wage bill in H in relation to total income. The effect is diminished in proportion to share of H sector employment in total manufacturing employment. For $E_J$ and $E_T \neq 0$, the overall welfare effect of the tariff depends on these direct and indirect real income effects as well as endogenous changes in $J$ and $T$. 


References


Table 1:
GDP growth rates and shares of major sectors (%), developing Asian countries

<table>
<thead>
<tr>
<th>Country</th>
<th>GDP growth&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Years</th>
<th>Agric.</th>
<th>Industry (Mfg)</th>
<th>Services</th>
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<td>Indonesia</td>
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<td>1960-80</td>
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<td>23</td>
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<td></td>
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<td></td>
<td>1991-00</td>
<td>18</td>
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<td>30</td>
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<td></td>
<td></td>
<td>1981-90</td>
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<td>21</td>
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<td></td>
<td></td>
<td>1991-00</td>
<td>13</td>
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<td></td>
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<td></td>
<td>1991-00</td>
<td>20</td>
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<td>23</td>
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<td>1960-80</td>
<td>29</td>
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<td></td>
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<tr>
<td>Vietnam</td>
<td>5.37&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>..</td>
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<td></td>
<td>1991-00</td>
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Table 2: Estimated changes in natural forest and plantation cover

<table>
<thead>
<tr>
<th>Region</th>
<th>1990 ('000 ha)</th>
<th>2000 ('000 ha)</th>
<th>Average annual change of natural forest</th>
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<td>plantation</td>
<td>Nat. forest</td>
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<td>Oceania</td>
<td>36,201</td>
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<td>903,199</td>
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<td>56,117</td>
<td>431,422</td>
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<td>—Tropical</td>
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<tr>
<td>—Temperate</td>
<td>205,520</td>
<td>33,631</td>
<td>197,974</td>
</tr>
</tbody>
</table>

Source: World Resources Institute calculations from FAO data (Matthews 2001).
FIGURE 1

Panel (a): Agriculture
Panel (b): Labor market
Panel (c): Manufacturing
FIGURE 2: INCREASE IN UPLAND AGRICULTURAL PRICE